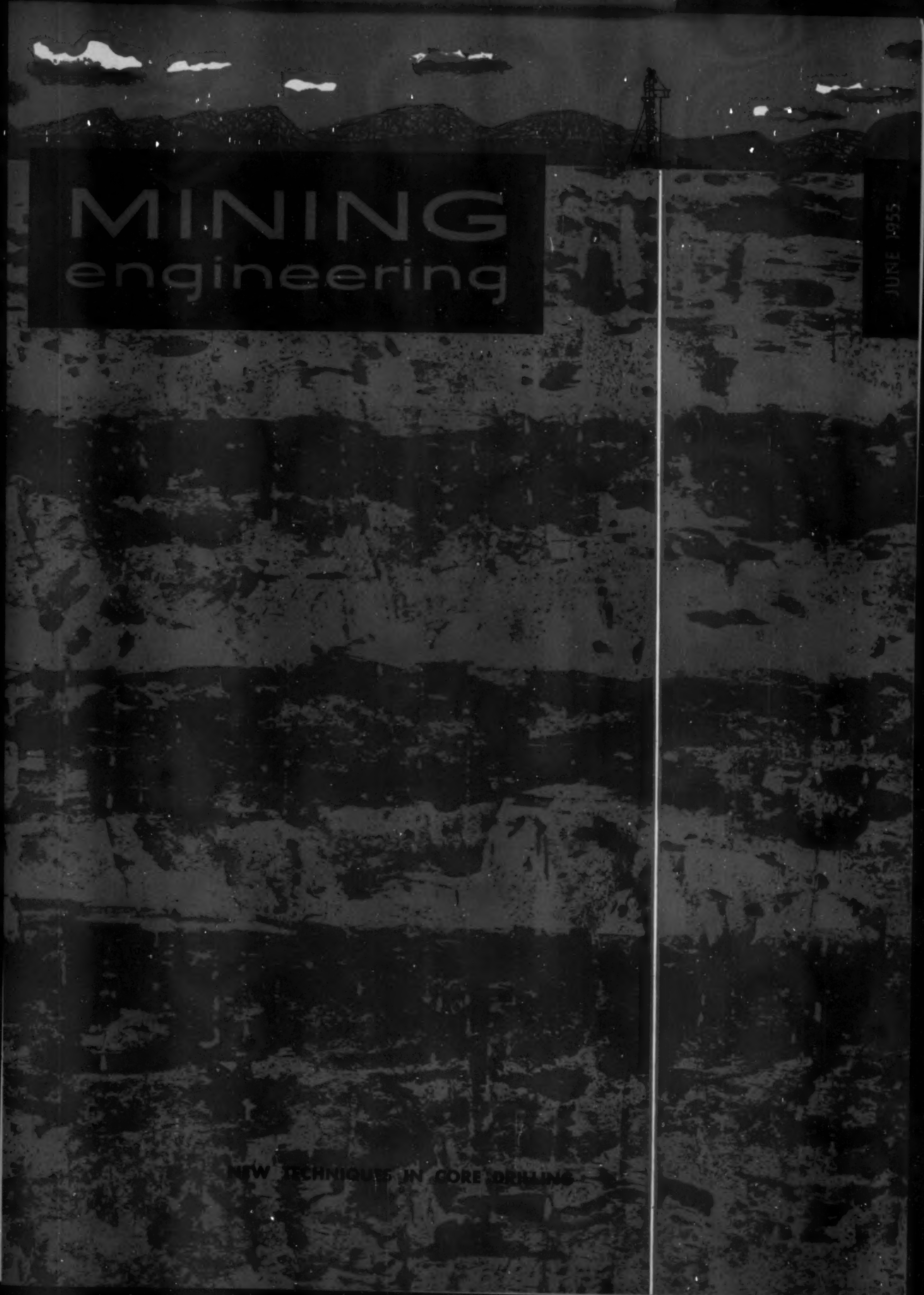
MINING engineering

JUNE 1955



NEW TECHNIQUES IN CORE DRILLING

MINING engineering

VOL. 7 NO. 6 JUNE 1955

COVER

Artist Herb McClure's cover draws attention to one of the latest techniques in core drilling—the wire-line core barrel. Turn to page 548 for complete details on this new tool for deep drilling.

FEATURES

ARTICLES

TRANSACTIONS

The AIME also publishes **Journal of Metals** and **Journal of Petroleum Technology.**

Published monthly by the American Institute of Mining and Metallurgical Engineers, Inc., 29 West 39th St., New York 18, N. Y. Telephone: PEnnsylvania 6-9220. Subscription $8 per year for non-AIME members in the U. S., & North, South & Central America; $10 foreign; $6 for AIME members, or $4 additional in combination with a subscription to "Journal of Metals" or "Journal of Petroleum Technology". Single copies $.75; single copies foreign $1.00, special issues $1.50. The AIME is not responsible for any statement made or opinion expressed in its publication. Registered cable address, AIME, New York. Indexed in Engineering Index, Industrial Arts Index, and by The National Research Bureau. Entered as second-class matter Jan. 18, 1949, at the post office at N. Y., N. Y., under the act of March 3, 1879. Additional entry established in Manchester, N. H. Member, ABC.

PERSONNEL

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Geological Engineer, 28, married; children; B.S. geological engineering, M.S. geology. Four years experience ground water geology and hydraulics, refraction seismic and earth resistivity methods, subsurface and areal geology, professional report writing. Desires position in which geological experience may be applied to engineering practice. M-228.

Mining Engineer, B.S., M.S. mining engineering, 28, single. Two years underground anthracite experience, one year bituminous, 2½ years pump application engineering. Desires position with equipment sales or engineering concern. Available immediately. M-226.

Mining Engineer, 35, single, U. S. citizen, veteran. Has limited experience and desires position with greater opportunities in any department of mining industry or highway construction, preferably in U. S. M-225.

POSITIONS OPEN

Chemist and Assayer with laboratory experience on analysis of tin, zinc tungsten ores. Salary open. Location, South. W1480.

Resident Engineer, mining engineer or geologist, with exploration and diamond drilling experience covering iron ore deposits. Salary, $800 to $1000 a month. Location, eastern Bolivia. F1464.

Staff Engineer, mining graduate, with considerable bituminous coal experience covering property examinations, production, cost analysis, and managerial experience. Salary open. Location, Pennsylvania. W1421.

Mining Engineer for technical service. Work involves development, manufacture, sales, and use of commercial explosives. Recent graduate or man with limited experience preferred. Location, Southwest. W1369.

Mining Engineer with mining and milling experience for supervisory and engineering duties at open pit manganese mine. Salary, $6000 to $8000 a year. In Virginia. W1440.

Metallurgists or Metallurgical Engineers, under 40, to do applied research in ferrous or nonferrous, physical process, foundry, welding, ore dressing, metallography, or related work in metallurgy. Location, Midwest. W1492.

Mine Superintendent, for small open cut manganese property. Must be thoroughly familiar with stripping, milling, blasting, and material handling operations. Should be 35 to 45 and not necessarily a graduate engineer. Salary open. Location, West. W1466.

Metallurgical Engineer with 3 to 7 years experience in hydrometallurgy for an expanding lithium chemical processing plant. Salary open. Location, South. W1452.

Industrial Publicist, 28 to 32, M.E. or metallurgical engineering graduate, with experience to make field surveys, select material, and prepare articles for technical journals. Some traveling. Salary, $6000 to $7000 a year. Location, Ohio. W1387.

Superintendent, graduate mining engineer, experienced in supervision of open pit mine and milling operations for asbestos project. Spanish desirable. Salary, $10,000 to $12,000 a year, plus housing. Location, Venezuela. F1537.

WANTED: Qualified Assistant Mine Superintendent. Want man with broad mining experience, acquainted with square set stoping. Must be able to handle labor. 1000-ton per day operation. Graduate engineer preferred, age 35-45. Housing furnished, excellent climate, location Southeast, salary commensurate with ability. Full record required in first reply.
Write: Box 7-G, MINING ENGINEERING, 29 West 39th St., New York 18, N. Y.

POSITION AVAILABLE
Graduate engineer to manage mining property producing two hundred tons per day, located in the Andes of Southern Peru. Must speak Spanish, preferably Latin-American operating experience. Send professional record and salary desired to:
Box 5-F AIME
29 West 39th St., New York

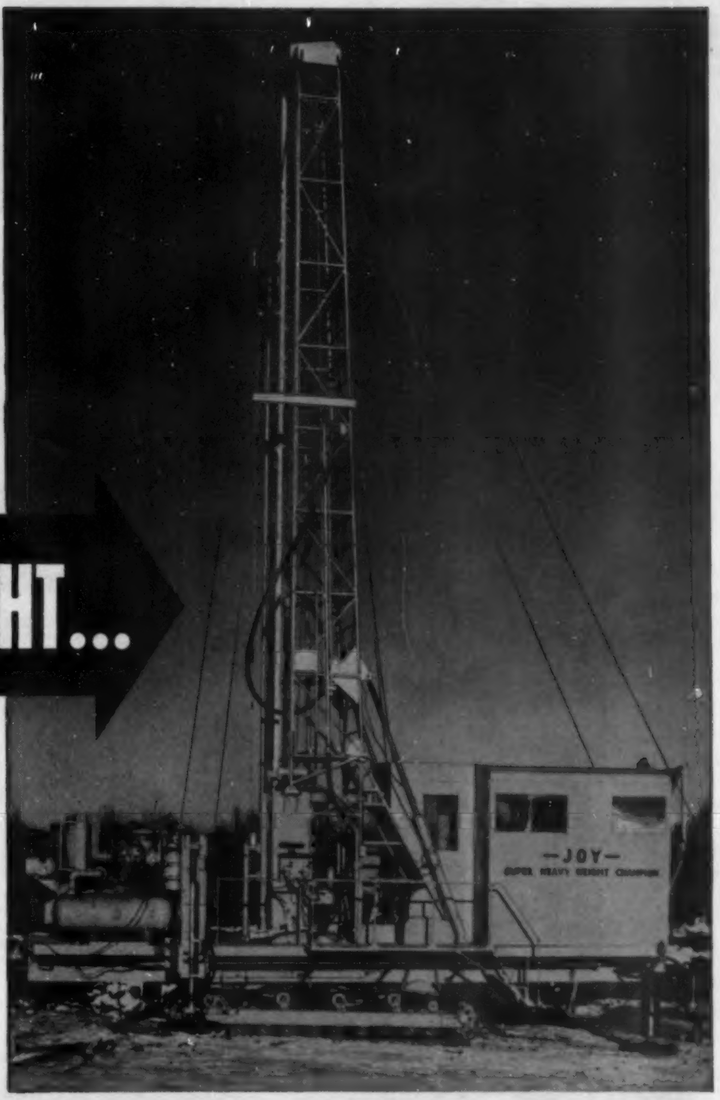
POSITION AVAILABLE
Graduate engineer thoroughly experienced open-cut mining, preferably with Latin-American operating background needed for preparation estimates later operation location South America, salary open. Send full professional record, salary desired, references.
Box 6-F AIME
29 West 39th St., New York

Ore Dressing Engineer and Technicians, to handle test work in commercial laboratory. Preliminary and pilot mill work for process determination. Excellent opportunity to grow with a small progressive organization. Salary commensurate with experience and ability. Location Florida.
Box 8-G AIME
29 West 39th St. New York 18, N. Y.

MEET "BIG BROTHER"

... the 60-BH

SUPER HEAVYWEIGHT...



CHAMPION BLASTHOLE DRILL

Here is the new, *larger,* heavier Joy Champion Rotary Blasthole Drill . . . the "big brother" of the Middleweight and Heavyweight Champions, the Joy drills which pioneered revolutionary rotary-air blast drilling. It is designed specifically for large (9" to 12") hole-drilling in harder rock.

Proof of its ability to tackle the toughest open cut mining and quarry jobs is the record of the unit illustrated. This Super Heavyweight has been performing very satisfactorily in the hard taconite formations of the Minnesota Iron Range.

The 60-BH Super Heavyweight is a rugged, heavy-duty, low maintenance machine, built to last and produce. Write, now, for complete details to *Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.* In Canada: *Joy Manufacturing Company (Canada) Limited, Galt, Ontario.*

Check these super heavyweight features:

DRILLS DRY . . . No freezing water lines, no costly water hauling.

NO LOST HOLES . . . Rigid drilling stem, controllable feed pressure, infinitely variable rotation speed prevent bit wander.

QUICK SETUP . . . *Hydraulically raised mast* and hydraulic levelling jacks.

DRILLS CLEAN . . . Continuous, instant removal of cuttings by a blast of compressed air.

HYDRAULIC CHUCK . . . Full automatic and self-aligning.

AMPLE WEIGHT . . . Enough to handle big 9" to 12" holes.

Consult a Joy Engineer

for AIR COMPRESSORS • ROCK DRILLS • WAGON DRILLS
CORE DRILLS • BLASTHOLE DRILLS • PORTABLE HOISTS
FANS • BLOWERS • HYDRAULIC HOSE AND COUPLINGS

WaD M5542

JOY

PIONEER AND WORLD'S LARGEST MANUFACTURER OF ROTARY BLAST HOLE DRILLS

ATLAS COPCO EQUIPMENT SENT TO ARCTIC MINING EXPEDITION

In 1952, an enterprising Danish company, Nordisk Mineselskab A/S, began arduous exploratory work and extensive trial drilling in the mountainous, uninhabited arctic area of East Greenland. They were after supposedly rich deposits of lead and zinc...

The ship bringing one of the first prospecting teams in the ice off Greenland.

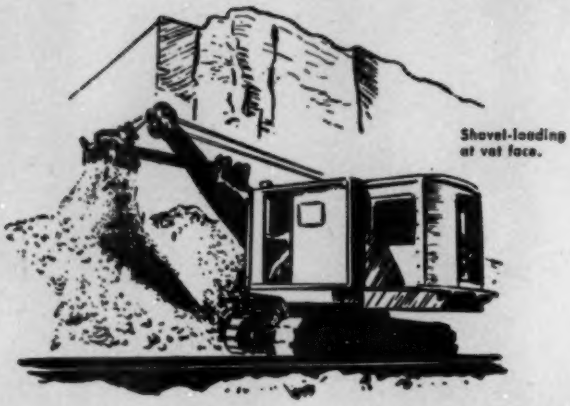
6,500 FEET OF TEST TUNNELS

From the Danish company in the Atlas Copco Group, C. K. Alling A/S, came Atlas Copco rock drills and Sandvik Coromant tungsten-carbide-tipped drill steels to King Oscar's fjord—the site of the mining expedition. Whether these deposits of minerals existed in any worthwhile quantity could now be determined and the equipment was set to work drilling numerous test tunnels—totalling 6,500 feet in length. The results were good. So good, that large-scale mining will start shortly and the first consignments are expected to reach Denmark in about two years time.

MILL INSIDE MOUNTAIN

An unusual feature of this project is the location of the mill for the extraction of the ore. Due to Greenland's arctic temperatures, this will be situated inside the mountain in which mining will take place.

Experts estimate that the mine will yield an annual production of 70-80,000 tons of ore, giving 10,000 tons of lead concentrate and the same quantity of zinc blend concentrate.


Shovel-loading
at vat face.

BOOKS

The Geology of the Cuyuna District, Minnesota, A Progress Report, by Frank F. Grout and J. F. Wolff, Sr., *University of Minnesota Press,* Bulletin 36, $3.00, 144 pp., 1955.— Mr. Wolff is now retired from his post as general mining engineer and from a later appointment as engineering consultant, Oliver Iron Mining Div., U. S. Steel Corp. Mr. Grout is emeritus professor of geology and mineralogy, University of Minnesota, and a geologist of the Minnesota Geological Survey. Their book is the only major report on this district in 36 years. It emphasizes initially the subdivision of the Cuyuna district into a north and south range, the former containing iron-bearing rocks comparable with those of the Mesabi district and its Michigan and Wisconsin equivalents and the latter being the equivalent of the younger Michigan iron formations.

Professional Engineering Registration Laws, compiled and published by *Alfred L. McCawley.* $8.75, 614 pp., 1954.—The culmination of extensive research under the sponsorship of the National Society of Professional Engineers, this book presents state by state legal requirements for professional practice. It covers in detail such elements of state law as temporary permits, fees and bonds, the filing of maps, certificate applications, education requirements, examinations, and public works projects. Laws are cited for reciprocity, registration renewals, corporate and partnership practice, revocation of registration, and violations and penalties.

ORDER YOUR BOOKS THROUGH AIME—Address Irene K. Sharp, Book Department. Ten pct discount given whenever possible.

Heating Ventilating Air Conditioning Guide 1955, *American Society of Heating and Air-Conditioning Engineers,* New York, $12.00, 1680 pp., 33rd ed., edged indexed.—Extensive revision and expansion in this edition are the result of research by the Society and others, changes in codes and standards, new methods in product design, and improved engineering practices. The technical section contains 1160 pages and the equipment section has data on the products of 328 manufacturers. A 24x32-in. ASHAE psychrometric chart is included.

Advances in Geophysics, Volume II: 1955, edited by H. E. Landsberg, *Academic Press Inc.* $7.50, 286 pp., 1955.—The editor is with the U. S. Weather Bureau. Contents include: "Advances in Radar Weather," "Wind Generated Gravity Waves," "Geological Chronometry by Radioactive Methods," and "Earthquake Seismographs and Associated Instruments."

Please Order the Publications Listed Below from the Publishers

Tectonic Map of the Colorado Plateau Showing Uranium Deposits, by Vincent C. Kelley, *University of New Mexico* Publications in Geology No. 5, Fig. 2, $1.00. Prepared in cooperation with the AEC. Sheet size: 26x32 in., 5 colors, folded in pocket, scale: 1:16. Lists and locates 421 structures including those for oil and gas and 89 better-known uranium deposits. The publication, **Regional Tectonics of the Colorado Plateau and Relationship to the Origin and Distribution of Uranium,** of which the above map is one of the figures may also be obtained with the map for $2.00 or without the map for $1.00. Available from Editor of Publications, University of New Mexico, Albuquerque, N. M.

Bauxite in Australia, by H. B. Owen, *Dept. of National Development,* Bureau of Mineral Resources, Geology, and Geophysics, Canberra, Australia, Bulletin 24, free, 234 pp., 27 pl., 1954.—Present production of bauxite in Australia is relatively small and averages about 5000 tons annually. Principal purpose of this bulletin is to record the results of exploration from 1945 to 1952.

Please Order Publications on this Page from the Publishers

The Economics of United States and World Oil, by E. Ospina-Racines, *E. Ospina-Racines,* Apartado Aereo 49-45, Bogota, Colombia, $5.00 plus 50¢ shipping charge anywhere in the world, 194 pp. mimeographed text, 37 printed graphs, 70 tables.—First published in 1950, this is the same text as the $25.00 edition. It was reviewed by Walter H. Voskuil in the November 1951 bulletin of the AAPG as "an excellent contribution to a study of international economics of the oil industry . . . The effect of supply-demand relationships upon trends and in the price of crude oil, the factors that cause a time-lag in price and supply readjustments, are carefully analyzed with supporting data.

Effect of Fine Particle Sizes on Sulfide Flotation, by Arthur P. Wichmann and Roshan Boman Bhappu, *Quarterly,* Vol. 50, No. 2, Colorado School of Mines, Golden, Colo., $1.00, 37 pp., April 1955.—Mr. Wichmann is professor of metallurgy, Colorado School of Mines, and Mr. Bhappu is a metallurgist with Miami Copper Co. Illustrated.

Colorado Plateau Uranium Deposits. Map MF 16. Preliminary geologic map showing the distribution of uranium deposits and principal ore-bearing formations of the Colorado Plateau region, compiled by W. I. Finch, 1955, 50¢. A short text printed on the map gives the production history, general geology, and briefly describes major formations and deposits. Available from Distribution Section, Geological Survey, Denver Federal Center, Denver, Colo.

Synthetic Liquid Fuels, Annual Report of the Secretary of the Interior for 1954, Part I, Oil From Coal, RI 5118, 73 pp., **Part II, Oil From Oil Shale,** RI 5119, 115 pp. Available free from *Bureau of Mines,* Publications Distribution Section, 4800 Forbes St., Pittsburgh 13, Pa. RI numbers and titles should be indicated.

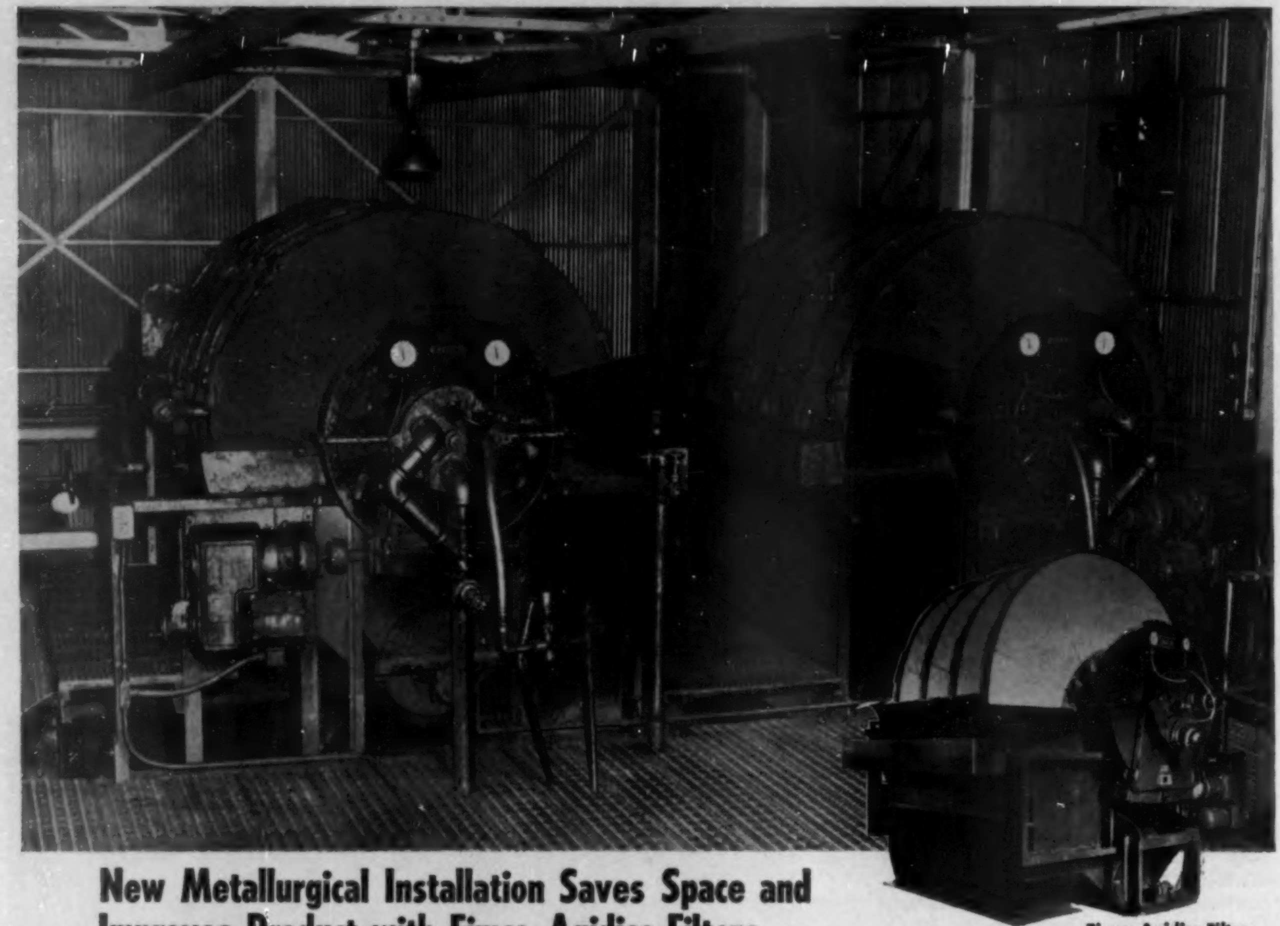
Transactions of the Southeastern Seminar on Spectroscopy, University of Florida, Feb. 17 to 19, 1954, Bulletin Series No. 68, *Florida Engineering and Industrial Experiment Station,* University of Florida, Gainesville, Fla., $1.00 35 pp., September 1954.

Geophysical Methods Applied to Geologic Problems in Wisconsin, by George P. Woollard and George F. Hanson, Bulletin 78, Scientific Series No. 15, *Wisconsin Geological Survey,* University of Wisconsin, Madison, Wis., $2.00, 255 pp., 115 fig., 1954.—How geophysical studies can be of assistance in resolving some of the problems of subsurface water supply, mineral exploration, engineering, and subsurface geology encountered in Wisconsin.

The Birth and Development of the Geological Sciences, by Frank Dawson Adams, *Dover Publications,* 920 Broadway, New York 10, N. Y., $1.95 paper cover, 511 pp., 91 ill., 1955.—First published in 1938, this report on 500-odd writers from Aristotle to Lyell contains accounts of mediaeval mineralogy, earthquakes, theories of the origin of the earth, assaying, and other interesting aspects of earth sciences. According to a reviewer in *The Journal of Geology,* geologists owe the author "a profound debt of gratitude for making available to them, in delightful form, the all too little known foibles of their scientific forefathers."

Pipe Friction Manual, *Hydraulic Institute,* 122 E. 42nd St., New York 17, N. Y., domestic $1.75, foreign $1.85, 87 pp., 1954.—This manual is the result of an investigation undertaken to revise pipe friction data contained in the Institute's earlier edition, *Tentative Standards of Hydraulic Institute—Pipe Friction.* Material is based on latest information.

Preliminary Report on Coated Lightweight Concrete Aggregate from Canadian Clays and Shales, Part VI, British Columbia, by H. S. Wilson, *Dept. of Mines & Technical Surveys,* Mines Branch, Ottawa, Canada, 50¢ Can., 42 pp., 1954.



Eimco Agidisc Filter

New Metallurgical Installation Saves Space and Improves Product with Eimco Agidisc Filters

The photo above shows an installation of two 6' diameter by 5 disc Eimco Agidisc Filters in their operating position in a new metallurgical concentrating plant.

These filters were installed as a result of the owner company and Eimco cooperation in a joint effort to improve the operation of the filter station at this plant and reduce moistures with the most economical equipment.

After the installation had been operating for six months the following data was made available.

	PREVIOUS EQUIPMENT	NEW EIMCO FILTERS
1. Concentrate handled	350,000 lbs./24 hrs.	350,000 lbs./24 hrs.
2. Labor required	1 man full time	1 man part time
3. Attention required	Constant inspection	Periodical inspection every 6-8 hrs.
4. Operating Capacity	Full load—no capacity for additional tonnage	½-¾ load—capacity for 33% to 100% additional tonnage
5. Equipment	4—Drum filters (not Eimco)	2—6' dia. x 5 disc Eimco Agidiscs
6. Filter area	621 sq. ft.	500 sq. ft.
7. Floor Space occupied	416 sq. ft. filters only	189 sq. ft. filters only
8. Cake Moisture	20%—21%	14%—15%
9. % Moisture reduction over previous method		33%
10. Filter rate increase over previous method		more than 15%

Eimco specializes in equipment to do a better job in filtration. Before you buy, take advantage of Eimco's experience in building filtration equipment for customers who look beyond first cost to get quality construction, individual design and guaranteed performance.

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B-102

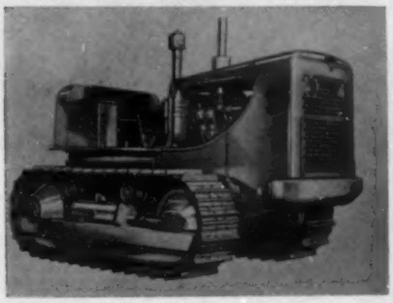
Manufacturers News

News
Equipment
Catalogs

• FILL OUT THE CARD FOR MORE INFORMATION •

Crawler Tractor

The 31,500 lb HD-16 crawler tractor, built by *Allis-Chalmers Tractor Div.*, is available with torque converter or standard transmission. The new A-C 6-cylinder, 844-cu in.



diesel engine develops 150 hp at 1800 rpm with torque converter or 140 hp at 1600 rpm with standard transmission. **Circle No. 1**

Fuel System

An entirely new fuel system designed around the Roosa-Master pump is now standard equipment on all *Harnischfeger Corp.* diesel engines. The new pump, engineered strictly for P&H diesels, was developed in cooperation between Harnischfeger and builders of the pump, Hartford Machine Screw Co. **Circle No. 2**

Drilling Rig

Gardner-Denver's Air Trac, self-propelled drill carried with crawler tracks, is said to be especially

adapted to rough and steep terrain. Mobility permits operator to spot holes rapidly and accurately. Traction power is sufficient to haul a 6-ton compressor up a 10 pct grade. **Circle No. 3**

Soil Analysis

Edmund Scientific Corp. has developed a new instrument for soil analysis, the Edscorp geological sand measuring magnifier. The unit is designed to measure, count, and compare sand particles under 6X magnification. **Circle No. 4**

Conveyor Belt

A new conveyor belt reported to be 400 pct stronger than conventional cotton reinforced belts is being produced by *Hewitt-Robins Inc.* The belt is reinforced with a new synthetic fabric, Super Raynile. It is less expensive than steel-reinforced belts. **Circle No. 5**

Seismic Magnetic Recorder

Houston Technical Laboratories has started commercial production of the first seismic magnetic recorder

to use a disc as the recording medium. Trade-named MagneDISC, the instrument makes it possible to record up to 96 data channels on one plastic disc. **Circle No. 6**

Tractor Improvement

A new, more efficient D-8 tractor is offered in two models by *Caterpillar Tractor Co.* The two D-8 models have different drives—a torque converter (Series D) and a direct drive (Series E). Operating weight of the Series D is 41,265 lb and the Series E, 40,430 lb. **Circle No. 7**

Drill Rods

E. J. Longyear Co. has announced a complete line of drill rods developed to the new standards adopted by the Diamond Core Drill Mfrs. Assn. Overall increase in size is reported to make for more stabilized drill string with less vibration and a minimum of ground caving. **Circle No. 8**

Screening Plant

The Nolan Co. has entered into an agreement for production of the Hein, Lehmann radial screening plant. Cost, maintenance, weight, and floor space advantages are claimed for the plant. No driving agency is needed. **Circle No. 9**

Rock Drill

The triple duty IR Drillmaster is a self-contained drilling unit designed to speed up drilling of rock and provide a range of hole sizes and drilling depths hitherto not available

in a blasthole drill. The *Ingersoll-Rand* machine offers a choice of one or all three options: the new Depth-Master, the hammer drill Power-master, or the Roto-Master rotary drill. **Circle No. 10**

Earthmover

International Harvester's new 75 Payscraper stresses safety. Easy-to-operate controls are a feature of the largest, high-speed, rubber tired

earthmover in the International line. Better steering control is obtained by providing more hydraulic operating pressure to beef up the exclusive Hydro-Steer. **Circle No. 11**

Survey System

A new scintillation survey system for aerial and ground radioactivity exploration has been announced by *Nuclear Instrument & Chemical Corp.* The complete DS-7 system consists of a scintillation detector with a 3-in. sodium iodide crystal, a ratemeter, chart recorder, and buzzer alarm to alert pilot or observer. **Circle No. 12**

(Continued on page 516)

Mfrs. News Cont'd. . . . .

Twin-Power Tractor

Limited production is underway on the TC-12 twin-power crawler tractor introduced by the *Euclid Div.* of General Motors. The TC-12 has 40 pct more weight and 80 pct more power than tractors currently

in use. Arrangement of power train provides simple operation, smooth, steady flow of power, and greater drawbar pull at higher speed, according to the company. **Circle No. 13**

Wire Rope

American Chain & Cable is now manufacturing a wire rope that is claimed to be 15 pct stronger in ½-in. to 2½-in. diam. The rope is reported to have an average tensile strength of 300,000 psi. **Circle No. 14**

Power Package

The first diesel-electric packaged power plant for the oil drilling industry was shipped recently from *ALCO Products Inc.* It was also first new product delivered by ALCO under its new name. The 118-year old corporation had been known as American Locomotive since 1901, and completed the name change in April 1955.

The power package consisted of two diesel engine generator sets skid-mounted for portability. Other units range in capacity from 550 to 2400 hp., and are designed for drilling to depths from 5000 to 15,000 ft. **Circle No. 15**

Horizontal Screen

A horizontal vibrating screen of new design has been added to the *Link-Belt Co.* line of equipment. The Straightline screen is suited for dewatering high capacity loads and sizing material where headroom is limited, as a result of its low silhouette design. Two vibrators, one on each side, are mounted at the center of gravity. Units are available in sizes from 4x8 to 6x20-ft, in one or two-deck models. **Circle No. 16**

News and Notes

MacAfee & Co., consulting mining and chemical engineers, has moved from the Oviatt Building, Los Angeles to 3105 Wilshire Blvd., Los Angeles. . . H. H. Fraser & Associates, Johannesburg, South Africa, and Paul Weir Co., Chicago, have formed *Fraser, Weir & Associates Inc.*, industrial consultants, with headquarters at 20 N. Wacker Drive, Chicago 6.

(21) NEW TRACTOR: Bulletin from *Caterpillar Tractor Co.* introduces the Cat D7 tractor, series C, said "to offer the greatest value of any tractor in its size and weight." Exclusive D7 oil clutch, 102 drawbar hp, 128 flywheel hp, and 28,700 lb of profitable drawbar pull are some of the reasons why.

(22) FLOTATION: Chemical Div., *Armour & Co.*, has a booklet on Armacs, acetic acid salts of fatty amines. Unique in their ability to be adsorbed onto metallic, and nonmetallic surfaces, these cationic materials have uses in combatting pipeline corrosion and in flotation.

(23) DIESEL & GAS ENGINES: *Nordberg Mfg. Co.'s* bulletin 239 describes Power Chief diesel and gas engines. Diesels, in 1, 2, 3-cyl models from 10 to 45 hp, are available with stub shaft or clutch power take-off and as engine-generator sets. Gas engines, built as power units and generator sets in 1 and 2-cyl models, are rated 18 hp and 36 hp max, respectively.

(24) HEAD PROTECTION: Bulletin 0600-3 from *Mine Safety Appliances Co.* shows a complete line of Skullgard protective helmets for miners, fire-fighters, and industrial workers. A pictorial essay traces each step in the molding of these helmets and explains testing processes employed to assure uniform standards.

(25) TANKS: Bulletin T2-B5 from *Denver Eqpt. Co.* gives construction, dimensions, specifications, and prices for bolted steel tanks, bolted steel thickener tanks, bolted steel tray tanks, welded steel tanks, and wood tanks. Also included is a complete description of overflow launders for every purpose.

(26) AIR CLASSIFIER: *Hardinge Co.'s* bulletin AH-467 discusses the operating principle and typical applications of the Gyrotor. This device for continuous separation of an airborne mixture of coarse and fine particles may be used as an independent sizing unit or in closed circuit with a grinding mill.

(27) COMPACT PUMP: *Allis-Chalmers'* Electrifugal pump, designed to keep cost per gallon pumped at rock bottom, requires only four bolts plus electrical, ground and pipe connections. Units are available in capacities to 2500 gpm, heads to 400 ft, and temperatures to 250 F.

(28) VALVE: Performance record of *Lunkenheimer Co.'s* "revolutionary" bronze globe valve is said to be due to two elements: a new seating metal, Brinalloy, and the flat-seat design of the valve. "Four years of tests prove there is no need for repair or replacement."

(29) URANIUM DETECTOR: *Nuclear-Chicago's* Oracle weighs less than 8 lb. Electronic circuit and batteries are in a 10x5x6-in. aluminum case. Other features include: a 0.1 pct uranium sample for calibration and comparison tests; readings as low as 0.001 mr/hr, long battery life, exclusive detector "pack."

(30) ROCK BOLTING HANDBOOK: *Ingersoll-Rand* terms its newly released 12-page bulletin 4155 the "most complete and authoritative report thus far produced on rock bolting methods, applications, and equipment."

(31) INDUSTRIAL CASTINGS: Typical applications of Absco metal castings are pictured in an 8-page folder from *American Brake Shoe Co.* Booklet describes material characteristics, lists properties, and carries engineering information on hardenability, section strength, and comparative properties of other cast metals.

(32) CONTROL DEVICES: *General Electric's* 68-page catalog on general purpose control devices has a special section correlating by horsepower components each type of motor control application. GEC-1260A also has photos, book prices, wiring diagrams, and dimensions on motor starters, contactors, relays, solenoids, switches, push buttons, and pilot devices.

Free Literature

(33) DIAMOND DRILLING: *Hillmac Corp.*, subsidiary of American Coldset Corp., has a 14-page brochure offering data on Shark Tooth diamond bits, Hillmac core barrels, and contract coring. Price lists are included. Equipment is sometimes rented.

(34) AIR & JEEP PROSPECTING: *Tracerlab Inc.* has a 4-page pamphlet on air and jeep-borne radioactivity surveying equipment. Folder shows special scintillation equipment for oil and uranium prospecting, gives a complete list of literature references, and provides specifications and prices.

(35) ENGINEERING: "Sauerman News" is published by *Sauerman Bros. Inc.*, engineers and manufacturers since 1909. Current issue has illustrated articles on a giant scraper for the U. S. Engineers, on removing a rock cofferdam, and on scraper storage at Lion Oil Co.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after Sept. 15, 1955—if mailed in U. S. or Canada

Please send me { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

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41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	Students should write direct to manufacturer.						

Name ______________________ Title ________

Company ______________________

Street ______________________

City and Zone ______________________ State ________

(36) MAGNETIC PULLEYS: *Homer Mfg. Co.'s* Hercules permanent magnetic pulley applications and features are outlined in the 8-page bulletin PY-260. These pulleys automatically remove tramp iron from sand, slag, ore, chemicals, coal, cement, gravel, and separate ferrous from nonferrous materials.

(37) INDUSTRIAL TELEVISION: Catalog E. 51 from *Radio Corp. of America* contains features, applications, and construction details on ITV-6 industrial television equipment for industrial application.

(38) DUCTILE IRON: The cast iron that can be bent is becoming an increasingly popular construction material. *International Nickel's* 30-page, illustrated booklet DI-25 contains case histories, specification tables for the seven main types of ductile irons, and charts comparing mechanical properties.

(39) SHOVEL PRODUCTION: Available from *Harnischfeger Corp.* is a reprint of "Improving Electric Shovel Production Through Better Coordination of Operating Motions," by W. J. Cherones, chief engineer, Electrical Application Div. The 12-page booklet makes a comparison between adjustable voltage systems and P&H Magnetorque coupling.

(40) ALL-WHEEL-DRIVE: An 8-page brochure from *Marmon-Herrington Co.* illustrates this company's All-Wheel-Drive Ford trucks. Given are applications, model descriptions, and specifications.

(41) FLEXIBLE COUPLINGS: *Thomas Flexible Coupling Co.'s* condensed engineering catalog, 51 A, has a chart and indexed pages that tell you "How to Select a Coupling."

(42) BULK CONVEYOR: Installations in a wide range of industries are shown in *Jervis B. Webb Co.'s* 12-page catalog on bulk conveyors for handling coal, sand, gravel, stone, and aggregate.

(43) TRACTOR ATTACHMENTS: With the right attachment your tractor becomes a dragline, backhoe, self-propelled hoist or portable crane. Pictured in "9 Profitable Minutes for Contractors" are the many different *Hyster Co.* job attachments for either new or used tractors.

(44) STRAINERS: *S. P. Kinney Engineers Inc.* has a 13-page strainer brochure. These strainers will remove fine suspended particles from raw or process water, and many other liquids. Pipeline sizes range from 2 to 48 in.

(45) BATTERIES: Spring edition of "Exide Topics," published by Exide Industrial Div., *Electric Storage Battery Co.*, contains articles on baseball, TV stage sets, the Navy Supply Corps., mine tractors, and aluminum.

(46) CONTROLS: Pneumatic control and transmission systems are dealt with in bulletin 1120 from *Minneapolis-Honeywell Regulator Co.* Plant operators will find information on how to tune pneumatic controllers to a process, how to introduce manual adjustments, and how to provide the best air supply.

(47) EARTHMOVING: A 24-page catalog from *International Harvester Co.* shows International hydraulic bullgrader and bulldozer blades matched to T-6, TD-6, T-9, TD-9, TD-14A, and TD-18A crawlers. Among features stressed are: balanced design, scientifically curved blade, easy angling and tilting, and durable construction.

(48) SAMPLERS: *Denver Eqpt. Co.'s* bulletin S1-B4 discusses automatic sampling, a recognized saving in modern plants, and its application to many problems. Shown are various samplers for use where dust is troublesome, headroom is limited, mixing of sample is required between sample cuts, or samples are required from points in the concentration circuit.

(49) CALCIUM CHLORIDE: *Dow Chemical Co.* has an 18-page, illustrated book, "Recommended Procedures in the Bulk Handling of Calcium Chloride." Bulk handling is based on Dow's development of Peladow, a high-test, pellet form of this chemical.

(50) HARD-SURFACING: *Rankin Mfg. Co.'s* 8-page Ranite catalog tells why and how hard-surfacing should be applied to obtain the best results. Suggested applications: crusher jaws, grizzley bars, shovel rollers, tractor rollers, etc.

(51) SLOPE LOADER: Incline shaft sinking on up to 100 pct grades (45°) is completely mechanized with the *Eimco* RockerShovel to load out the round. Bulletin, illustrated with photographs and drawings, also shows how standard machines may be easily converted to slope loaders.

(52) METAL GRATING: *Klemp Metal Grating Corp.* has a 16-page data and specification manual covering all types of grating, open steel floor armor, and stair treads. Information is also given on safe load tables, use of grating and allied products, and various types of drain grates.

(53) TRAMP IRON: Features of the Discardo cross-belt magnetic separator are explained in specification sheet 6910 from *Stearns Magnetic Inc.* This machine provides for positive removal of dangerous tramp iron before it damages machinery, automatic rejection of tramp iron from magnet, and safe operation.

(54) AUTOMATION: Bulletin 1882 from *U. S. Electrical Motors Inc.* is called "Automation Through Varitrol Control." Color photos and schematic drawings show how a pneumatic control in Varidrive motors increases and improves output of a customer's product, reduces waste, and saves time and manpower.

(55) PORTABLE PUMPS: Bulletin 1230-B1 shows the "simplest, sturdiest pump a contractor can use." *Worthington Corp.'s* Blue Brute self-priming centrifugal pump. All rating and capacity figures are listed in conformance with standards set by the Associated General Contractors of America Inc.

(56) CONTINUOUS MINER: Catalog G-107 lists facts about *Goodman Mfg. Co.'s* continuous miners. They are claimed to be the highest tonnage producing mining and loading machines available today for extracting coal from the solid seam.

(57) FILTER MEDIA: Bulletin from *Eimco Corp.* contains eight actual samples of Eimco filter media. Abrasion resistance, heat effect, and temperature limitations are listed as well as reactions to mineral and organic acids, alkalis, and other chemicals.

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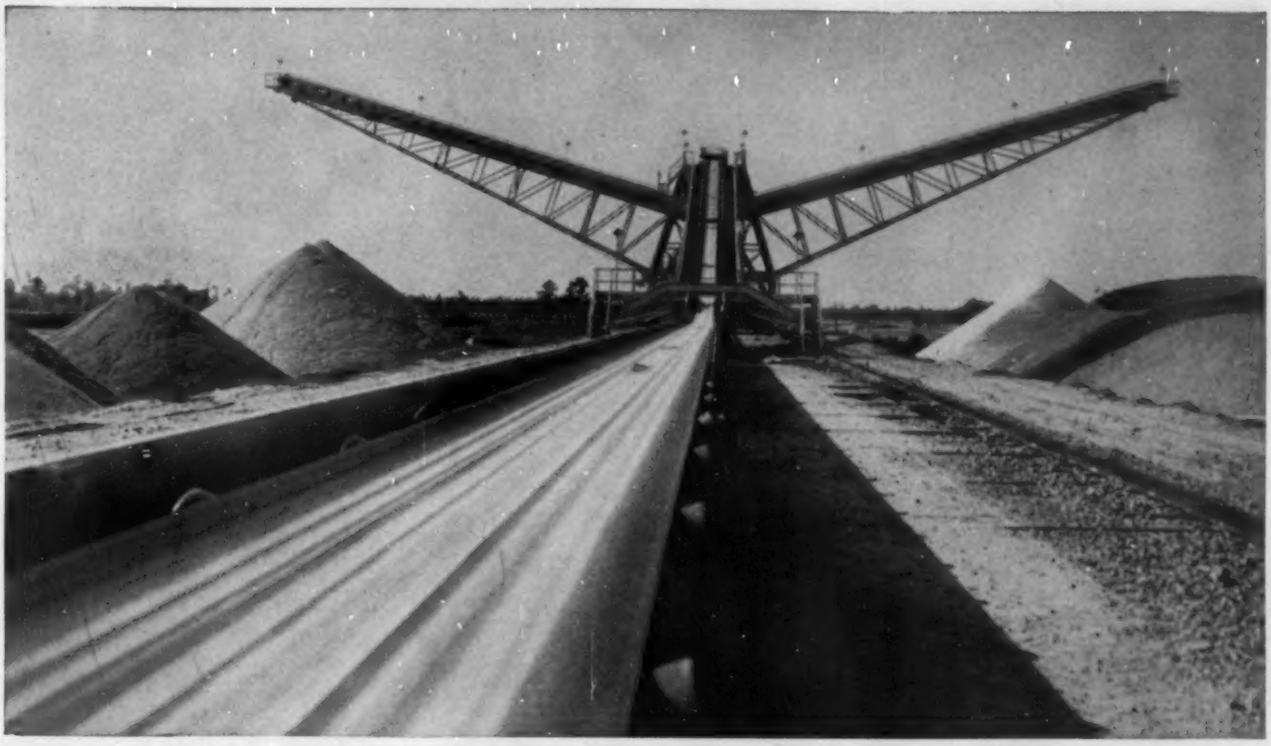


Stockpiles Phosphate Rock 7 Stories High—and Keeps Handling Costs at Rock Bottom

Stacker discharges 1088 foot center trunk line belt conveyor to either side. Rock is piled at a rate of 635 long tons per hour.

This giant traveling stacker has a "wingspread" of 220 feet and stands taller than a 7 story building. Engineered by S-A for the Virginia-Carolina Chemical Company's plant at Nichols, Florida, it stockpiles huge quantities of phosphate rock for drying prior to final moisture removal in a huge kiln. Rock moves from storage to the kiln via a tunnel belt conveyor system.

The phosphate rock is fed to the stacker wing conveyors by a 36-inch trunk line belt conveyor running on 1088 foot centers along the storage area. Rock flows to either of the two wing conveyors extending from the stacker tower at a rate of 635 long tons per hour. Rail clamps permit stationary operation of the stacker which forms piles about 90 feet high.

S-A "Simplex" carriers with spun end rollers turning on roller bearings protected by labyrinth seals are used on both trunk and boom belts. Other design features include S-A Hold-Backs which prevent belt reversal in case of power failure and Spring Type Belt Wipers which insure a clean belt surface in contact with the return rollers.

While a stacker piling rock 90 feet high may be beyond your needs, the same S-A engineering and manufacturing skill is available for your own specific problems—to help *you* handle *your* product at lowest cost per ton, using whatever type of bulk material handling equipment is best for you. Write, without obligation, for a free survey.

SINCE 1901 S-A STEPHENS-ADAMSON MFG. CO.

STEPHENS-ADAMSON MFG. CO.

37 Ridgeway Avenue, Aurora, Ill. • Los Angeles, Calif. • Belleville, Ont.

Engineering Division

Specialists in the design and manufacture of all types of bulk materials conveying systems.

Standard Products Division

A complete line of conveyor accessories including centrifugal loaders—car pullers—bin level controls—etc.

SealMaster Division

A complete line of industrial ball bearing units available in both standard and special housings.

Uranium-bearing Lignite Stirs Interest

Discovery of lignite coal containing significant quantities of U_3O_8 on the public domain in western North and South Dakota and eastern Montana created a great deal of uranium exploration activity. The Interior Dept. has been asked to rule on how rights may be obtained to mine the uraniferous lignites. The AEC is also expected to start metallurgical tests on the lignite.

Mexican Mines Operate at Slight Loss

American Metal Co. reports that its Mexican mines operated at a small loss during 1954 because of that country's tax setup. "For the year 1954, our mining operations provided export production and income taxes for the Mexican Government of more than $2.5 million."

"W" Series Drill Rods Standardized

The Diamond Core Drill Mfrs. Assn. announced that "W" series drill rods and couplings are now covered by dimensional standards. A similar announcement was made by the Canadian Diamond Drilling Assn. Complete dimensional interchangeability on an international basis is now possible in the EW, AW, BW, and NW sizes. The new sizes replace E, A, B, and N sizes formerly used in the U. S. and Canada.

Action in Alaska Steps Up

The Juneau, Alaska, office of the Territorial Dept. of Mines reports mining company representatives are coming through the office again. Interest in Alaskan mining properties seems higher than ever. American Smelting & Refining Co. is interested in copper, while Kennecott is returning for further prospecting and exploration. Newmont is also reported to have examined at least one Alaskan copper showing. Steel and iron mining firms are back this year looking for deposits. Requests have also been received at the office for information on asbestos, quartz, gypsum, mica, and other nonmetallics.

Offer Fixed Prices on Copper

Roan Antelope Copper Mines Ltd. and Mufulira Copper Mines Ltd. have decided to offer fixed prices for copper to customers in the United Kingdom who are willing and able to install a degree of stability in resale price of copper and brass products.

Reopen Zinc Operation in New Mexico

After being closed for almost two years, American Smelting & Refining Co.'s Groundhog mine at Vanadium, N. M., and the Deming, N. M., smelter were reopened. Announcement of the reopening followed an agreement with the union.

Atlas Focuses 3-D Camera On Blasting Research Project

Sequence Unit Traces Direction and Distance

Photography is one of the fastest growing methods for studying blasting techniques, and now Atlas Powder Co., Wilmington, Del., has come up with a 3-D sequence camera unit designed to study explosive action at work on actual jobs.

The new camera shoots four synchronized stereo-pairs a sec, showing the separate phases of the blast in three dimensions. The eyes of the stereo camera trace movement of burden both in direction and distance.

The stereoscopic camera assembly

This is the stereoscopic setup used by Atlas Powder Co. in its blasting research program. Shooting in sequence, the cameras can take four stereo pairs per sec.

consists of three units: camera unit, synchronizer, and power supply. The camera unit comprises two sequence cameras connected by bridge section mounted on a tripod. Cameras have shutter speeds of 1/200 sec and are fitted with matched lenses set in calibrated focusing mounts.

The interocular distance, or spacing between lenses, is changed by moving the cameras on the connecting bridge, enabling the unit to provide stereo shots for distances from 100 ft to infinity.

The synchronizer unit coordinates film advance, shutter operation, and flash timing. Hcused in a separate case and connected between the camera unit and power supply, the synchronizer controls operation of the entire mechanism. The camera can be remote-controlled from distances up to 250 ft away by a triggering cable. A separate 12-v dc battery powers the camera.

The stereo camera's predecessor was the machine gun camera. Atlas technical people expect the 3-D rig to contribute a great deal to the examination of blasting theory and methods.

Freeport Ships Liquid Sulphur Over Long Haul

Freeport Sulphur Co. inaugurated its new method for shipping sulphur over long distance water routes—as a liquid instead of a solid—when two of three specially equipped barges left Port Sulphur for a plant some 1100 miles up the Mississippi River.

Each of the insulated barges took on 2500 tons of melted sulphur at a temperature above the boiling point of water at Freeport's Port Sulphur docks. The shipment went to National Lead Co.'s titanium div. plant at St. Louis.

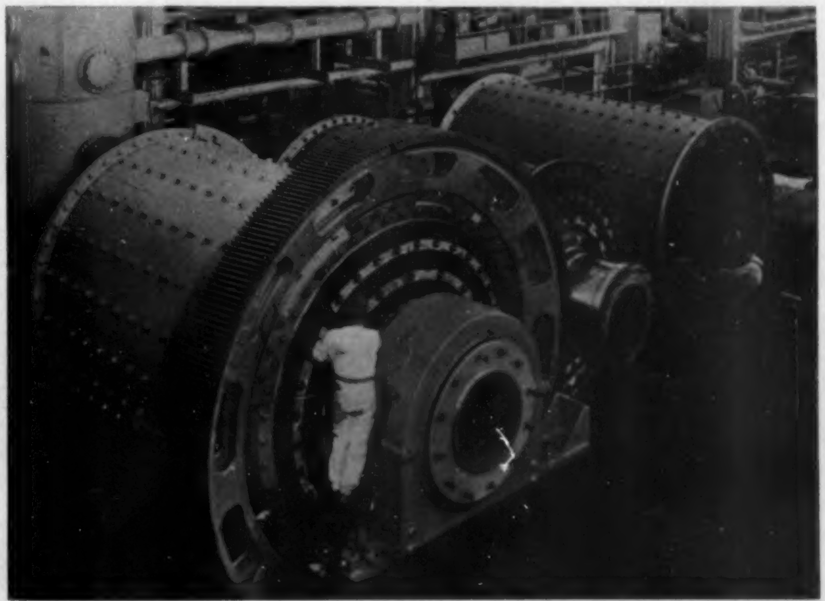
Built by Ingalls Shipbuilding Corp., the three barges are insulated with 4-in. thick foam glass and are equipped with boilers and heating coils to maintain a minimum temperature of 260°F, about 20° above sulphur's melting point.

Sulphur goes into the barges in the same liquid state that it is mined. By shipping in liquid form instead of solidifying the sulphur into chunks, dust loss is prevented, moisture avoided, contamination reduced, and remelting at consumption point eliminated.

Freeport began experiments with liquid sulphur transportation in 1948 between its Grand Ecaille mine and Port Sulphur, about a 10-mile trip. Early trials with a 600-ton capacity barge indicated that larger shipments over greater distances were practical.

In 1952 and 1953 the company developed two other mines, Bay Ste. Elaine and Garden Island Bay, in southern Louisiana. A fleet of seven 1000-ton barges was built to deliver the entire output of the two mines to Port Sulphur. From Bay Ste. Elaine the trip is 75 miles through bayous and coastal canals; the trip from Garden Island Bay starts in one of the shallow, winding passes at the Mississippi's mouth and goes 45 miles upstream.

Coyle Lines became the first commercial carrier to transport liquid sulphur in 1952 by placing in service a 1000-ton barge operating between the Moss Bluff mine of Texas Gulf Sulphur Co. and a sulphur-consuming plant about 50 miles away. The Freeport-National Lead haul is the first large quantity shipment of liquid sulphur over long distance water routes.



Allis-Chalmers is nearing completion on these three grinding mills of a group of 24, consisting of eight 10½x16-ft rod mills and sixteen 10½x14-ft ball mills, for a huge taconite development under construction in northern Minnesota. All of the mills are of the overflow type. They include fabricated trunnion bearings, antifriction pinion shaft bearings, cast steel one-piece heads, with special spout feeders for the rod mills and double scoop feeders for the ball mills. The units are equipped with one-piece gun-lock type single helical ring gear designed for repair bay service.

Brown's Run Mine Installs Streamlined Portal Building

Shift changing used to mean a kind of trial by confusion. Men coming out of a mine got mixed up with the shift going in, lost time at the lamp room, and possibly the worst thing, lost time between parking lot and shaft.

But operations at the new Brown's Run portal of the Emerald Coal & Coke Co. in Morgan Township, Greene County, Pa., are evidence that careful planning and design of a portal building can achieve maximum efficiency. Emerald opened the portal in July 1953 and enough time has passed to prove the efficiency of the system.

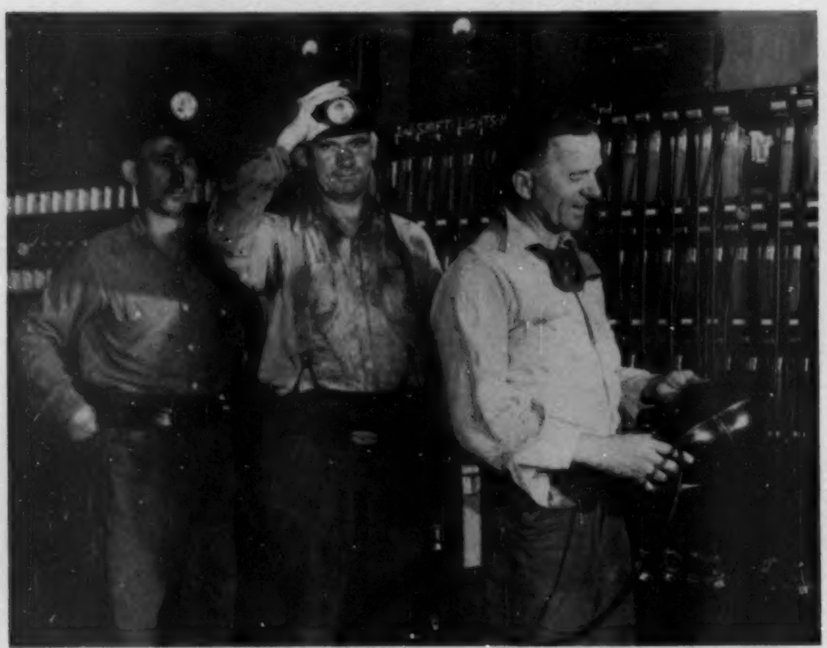
The building is designed around self-service distribution of miners' lamps, the Mine Safety Appliances Co. furnishing the new Edison R-4 cap lamps and charging equipment. The Emerald management says that since the self-service system was put in operation there has been a major reduction in the time necessary to distribute lamps to the men. Emerald employs 600 men on a three-shift basis, producing about 5600 tpd of Pittsburgh metallurgical seam coal.

Handrail separating incoming and outgoing shifts at the Brown's Run portal eliminates the confusion often accompanying shift changing. The corridor runs from the shaft to the portal building. From the time they leave the parking lot and enter the building the men are under one roof.

Under One Roof

The men now lose only few seconds between parking lot and elevator in picking up or leaving lamps. Confusion and waiting in line have been eliminated. The portal building is designed so the men are under roof at all times between the shaft and the double doorway that leads to the adjoining parking lot. The concrete block building is 152 ft long by 41 ft wide. A 14-ft wide corridor leads 42 ft to the modern 900-fpm electrically operated cage in the 467-ft shaft.

A handrail in the corridor divides incoming and outgoing shifts. As soon as one group of 30 miners leaves the shaft, another group is ready to board. The last things the miner sees before entering the elevator are the company slogan "Be Careful today, Buddy," and an illuminated flasher-type sign spelling out safety messages.



Self-service lamp distribution at Emerald has helped speed shift changes. Miners coming on or going off shift pick up and leave their own lamps at the charging racks. Lamp abuse has lowered considerably since the self-service operation was put into effect. It has also proved more economical and speedier than the old distribution system used at Emerald.

Lamp distribution is carried out in an area running about 60 ft from the entrance to the shaft corridor and the doorway to the parking lot. Charging racks are on both sides of the 16-ft wide room, and a 26-ft long bench is stationed in the center. The bench serves to separate incoming and outgoing crews and is also the repository for flame safety lamps used by men leaving the mine. Four magnetic openers for the Edison lamps are fixed to the bench. An extra bonus has accrued to the self-service center. The men, according to management, seem to handle their individual lamps more carefully.

One-man Operation

Operation cost of the lamp distribution center is substantially less than the previous method of standard distribution. Only one man is needed for lamp room operation during a shift. He also maintains about 45 flame safety lamps, operates the supply room where safety equipment, drill points, and other tools are stored, and serves as attendant for the ventilating fan. He has various other miscellaneous duties, too.

All mine machinery—motor gen-

erators, air compressors, etc.—is located in a building detached from the portal structure. Audible and visible signals for the ventilating fan operation and circuit breakers are located in the lamp repair room and in the charging room, where they can be heard and seen at all times by the attendant on duty.

The portal building houses the payroll office, mine superintendent, and foreman. A well-stocked company store takes up about 650 sq ft in the building. The first-aid room is adjacent to the waiting area at the building end of the elevator corridor. The mine rescue station is on the second floor of the building.

Pittsburgh metallurgical seam coal, all of which is mined mechanically, is moved to a combination washing and loading plant on the Monongahela River, about 5.4 miles from the Brown's Run portal. Mine shops are at the old portal 3 miles from the new shaft.

Emerald's self-service lamp distribution center is arranged to aid speedy movement of miners to and from work. Flame safety lamps are deposited on the bench in the middle of the room.

Osceola Mine Valve Opened by Spectacular Crosscut Operation

A 12-in. valve that was standing in the way of the dewatering of the Osceola mine of the Calumet Div. of Calumet & Hecla at Calumet, Mich., has finally been opened.

Civilian and Navy divers made several unsuccessful but spectacular attempts to close the valve by diving into the 370-ft inclined descent through pitch-black waters. *(See* MINING ENGINEERING, *March 1955)* When the divers failed to reach the valve, which was 140 ft inside a tunnel, underground crews of the Calumet Div. drove a 750-ft underground crosscut to provide passage for the water. The job was done in a record 25 work days. Pumping through the crosscut began January 22.

More than 200 million gal had to be pumped to get at the valve and 12-in. pipeline. The valve was opened February 28. On the unwatered mine level, Calumet officials were able to trace the route of the Navy diver who made a final attempt to reach the valve. His farthest point into the tunnel, 35 ft, was marked by a reel he dropped when time ran out and he was forced to turn back. Also discovered were two flashlights dropped by divers while groping their way through the water.

Oscar Archambeault tugs at the valve. With the valve open, the unwatering is going forward.

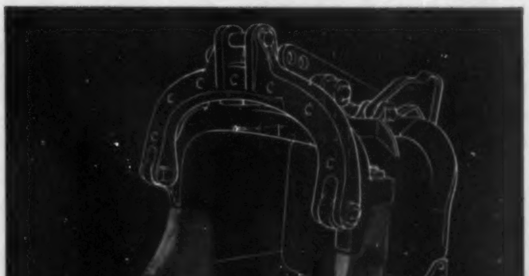
This is part of the route the divers would have had to cover to reach the valve. A. J. Bracco, foreground, foreman of the Osceola No. 13 mine, looks down the 90-ft, 28th level crosscut.

Valve in Good Shape

With the valve open, pumping through the 12-in. pipeline started March 3, using two small, auxiliary pumps. These two pumps will do the job until a 450-hp submersible pump can be lowered from the pipeline level to the bottom of the inclined shaft, about 1050 ft.

After this part of the unwatering is completed the only task to be faced will be the unwatering of an adjacent shaft of about 1400 inclined ft.

Head Mining Captain Oscar Archambeault reports that the valve and pipeline are both in good condition, despite 15 years under water. He says that he applied "only about 50-lb pressure" to open the valve.



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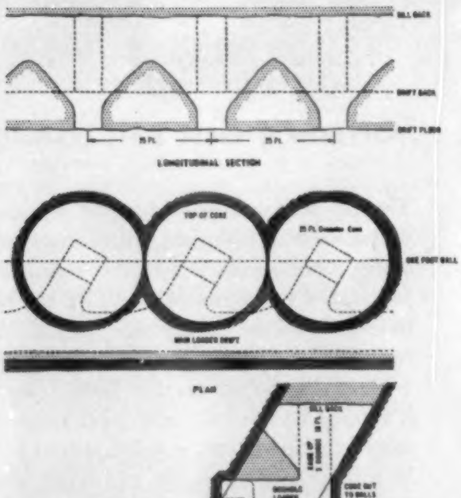
Yes! You can increase production and lower costs by using Eimco loaders to load your production tonnage.

The advantages of being able to load larger pieces, use less powder, practically eliminate secondary blasting and absolutely eliminate expensive chutes and grizzlies, will enable your mine to get into production in a new area faster at less expense.

That's why so many mining men are traveling to see mines that have changed their systems to production loading with Eimcos.

Many different ideas for saving time and lowering costs have been developed by operators to fit their particular conditions. A sketch of one of these is at right. Eimco engineers have helped work out numerous systems, they will be glad to help you. Write Eimco for information.



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You Can't Beat An Eimco

B74

JESSE C. JOHNSON, director of the Atomic Energy Commission's raw materials div., disclosed that "only three or four years ago there were fears that the military program might be restricted by shortages of uranium." That the situation has improved can be surmised from his statement that uranium "rapidly is becoming just another strategic material."

The Free World no longer has to worry about its supply of uranium. It has under development and production in the moderate cost category a possible 1 to 2 million tons. He also told the Atomic Industrial Forum, meeting in San Francisco, that resources from proven higher-cost facilities could be measured "in terms of many millions of tons."

There are still vast amounts of uranium in the West that have yet to be discovered. "New discoveries are adding uranium reserves faster than they are being mined." The Interior Dept., in a recent report, says that the growing interest in uranium is reflected by a marked increase in the number of applications for exploration assistance filed with the Defense Minerals Exploration Administration. In the three-month period ending Mar. 31, 1955 some 117 new applications were received, with 59 for uranium projects.

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FATHERS are inviting male offspring into the library for that momentous conversation and instead of talking about the birds and the bees are telling the lads the facts of engineering. "Son," the conversation goes, "if you want to own a racehorse, eat caviar, and drink vintage champagne, just get yourself an engineering degree. Any old degree will do, just so it says engineer on it."

Dad may be right at that, but more sober members of the community are doing some heavy thinking about the engineer shortage. In fact, *Business Week* throws some cold water on Dad's advice when it says, ". . . the demand for engineers generally seems to be neither greater nor less than it has been since the war."

It substantiates the argument by stating that there is not a shortage of all kinds of engineers, nor a shortage in every community. There are areas where there are shortages of engineers of a particular type, i.e., demand for specific talents. All regions, however, are looking for metallurgical, electrical, and to less extent mechanical engineers. Some places are beginning to need civil engineers. But aircraft, where one would expect a tremendous demand, has only a moderate need for aeronautical engineers.

The magazine feels that if one is looking for a single cause to blame the shortage it is the change that has taken place in aircraft manufacture. High performance and complicated construction has pitted aircraft makers and electronics firms against each other in the talent race. According to one source the ratio used to be one engineer for every 200 production men. With the ratio now one engineer for every 75 production workers, the day may come when there will be more engineers than production workers.

But in some areas the problem is strictly one of quality rather than quantity. Firms report that they can get all the engineers they want, except the kind that is typified as the "bright young man," the ones who keep the other engineers busy.

Engineering jobbing firms are blamed for the skyrocketing salary schedules. Those are the outfits that have tremendous periods of staff growth when a contract is being worked on, and then when the work is completed dehydrate to a skeleton organization. There is a great deal of open resentment against the jobber outfits. Because they can't give the security that a manufacturing firm offers they have to shove a needle into the salary scale to attract the talent needed.

What of the engineer himself? What does he want? Sure, a lot of them are asking for race horses, country club memberships, and pie in the sky now. But the vast majority seem to want an opportunity to do creative work. Salary, while figuring in their decisions, is not as important as one is led to believe. One engineer states that the need is not for engineers but technicians.

Recruiters, who have assumed an influential role heretofore never experienced, are aware of the desire to create. They are following the practice of emphasizing professional opportunity, living conditions, and creative opportunity.

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ONE of the most interesting things to come out of the Third National Air Pollution Symposium at Pasadena, Calif., was a proposal for a national air pollution abatement committee. The group, as conceived by William C. Foster, president of the Manufacturing Chemists' Assn., would be made up of state and federal officials, and industry representatives. The committee might serve in an advisory capacity to the President.

Mr. Foster pointed out that while air pollution is by nature a local problem, it is sufficiently widespread to require "national consideration." Mr. Foster offered no immediate solution to air pollution. He terms it one of the great single problems facing industry today. Some 68 bills have been introduced to 12 state legislatures. The Congress of the U. S. has another 20 bills in its hopper. Mr. Foster notes that some of the bills introduced around the nation are unduly restrictive.

Industry alone is not responsible for air pollution. Mr. Foster felt that industry had departed from its role of public whipping boy to some extent. "We have learned that the time has passed when pollution was a natural concomitant of production and the community involved could take it or leave it."

"A good deal of pollution exists today because of either indifference or ignorance," Mr. Foster said. Modern living has thrust several causes of air pollution upon the nation. They are: incinerators, private, public and industrial; open burning; and automobile exhausts. He points out that human traits enter into the situation. A man who owns a $1 million plant three years away from obsolescence, is going to "buck like a Brahma steer against spending $250,000 on air pollution abatement equipment." And "If you put up an apartment house last year with flue-fed incinerators, you're not going to take very kindly to the idea that they should now be immediately replaced."

Considerable research is needed into those areas of uncertainty which still exist. In spite of a tremendous mass of work being done by a huge number of people effective control measures for the elimination of all kinds of air pollution are still unavailable. Possible toxic effects of continued exposure to certain air pollutants is still not well understood.

Mr. Foster also expounded the necessity for a public information program. "The man in the street wants to know why his air is polluted and he wants to know what is being done to help his situation."

Mr. Foster sees his proposed committee performing several vitally needed jobs. It would coordinate industry support. Local interest would be properly represented. The committee would serve not only to collect information but to implement a national information effort. One short term goal might be to check air pollution so that it does not grow along with population.

THE chief resource of the U.S. is its technology. This is the conclusion of an economic report "America's Needs and Resources: A New Survey," by J. Frederic Dewhurst and associates, issued by the Twentieth Century Fund. The report investigates every part of the American economic system. It is the accumulated knowledge, techniques, and skills, and their application in creating useful goods and services which has made it possible to attain a per capita income five times higher than the world average. And the report predicts that income will go up in the coming years.

Mr. Dewhurst sums up the progress of the last 50 years by saying: "No period of comparable length in human history has brought such great changes in the variety, quality, and quantity of goods and services available for consumption. In many ways those of us now passing middle age have within our lifetime experienced a greater advance in our material standard of living and more pervasive change in our way of life than occurred in all the previous centuries of Western history."

It is Mr. Dewhurst's feeling that the mass of people have been the chief gainers from this great material progress. In his opinion the money gap between rich and poor has been narrowed by such factors as steeply progressive income taxes and inheritance taxes at the upper end of the economic scale, and increased relief and social security benefits at the lower end. But more important has been the trend toward "equalization of living standards" with new and improved products produced and distributed on a tremendous scale for mass consumption.

"Upper and lower income groups both use the same vacuum cleaners, refrigerators, deep freezers, oil burners, gas and electric stoves, radios and television sets. . . . They read the same newspapers and magazines, go to the same movies. . . . They smoke the same brands of cigarettes, drink the same frozen orange juice, eat the same canned, frozen, or out-of-season fresh food, bought at the same supermarket."

One of the points the survey makes is that it is a capitalistic society that has come closest to attaining the communist ideal of a classless society with enough for everyone.

Farm production is symbolic of the technological progress since 1900. Then an average farm worker produced enough for himself and seven others. Today the farm worker can produce enough for himself and 14 others. Similar advances are being made in equipping and running the American home. It is predicted that in the future people will spend more on furniture, decorations, and household conveniences than ever before—and will have the funds to spend. By 1960 it is expected that equipping and operating the home will cost more than rent, taking a larger share of income than any item except food.

The survey shows little fear of automation. "Instead of technological unemployment, we have enjoyed not only a vast increase in the amount and variety of goods available and a marked advance in our labor productivity, but also a steady rise in the number and proportion of the population in gainful occupations and a steady shortening of the work week. With some costly and painful interruptions, we have had our cake in the form of expanding employment, and eaten it in the form of increased leisure and an ever higher standard of living." The survey forecasts that automation will serve to relieve the worker of boredom just as mechanization helped to relieve him of physical fatigue.

Summing up the effects of many developments throughout our entire economic system, the survey concludes: "The material welfare of the American people and our progress during recent decades can be suggested by such measures as national income per capita and per family. . . . National income per capita in the U.S., for example, amounted to $1,585 in 1950; per family, or household, to $5,535. . . . Income per capita in this country in 1950 exceeded that of any other country and was probably five times the average for the world as a whole."

To do a big job fast, they called on the DW21s

When the picture was taken, this Caterpillar DW21 had been working 20 hours a day, six days a week for six consecutive weeks. It and five other DW21s had to move *four million tons of overburden in two months* from a copper pit at Kimberly, Nevada. Much of the material was frozen and hard to work, and some grades were 10% adverse. The DW21s and No. 21 Scrapers, together with three Caterpillar track-type Tractors and a No. 12 Motor Grader on the job, are owned by Young and Smith Construction Co. of Salt Lake City.

What's back of choosing DW21s for a big job like this? First of all, according to Elmo Longstroth, superintendent for Young and Smith, there's the ability of the DW21 to stand up to rough usage. It's designed as a unit, and matched to scraper capacity, for long life and top efficiency.

Heart of the DW21 is its big CAT* Diesel Engine, with 275 HP (A.S.M.E.).

The DW21 is easy and fast to handle. With the No. 21 Scraper, it can turn in a 35-ft. roadway. The load is taken on quickly, with a live, boiling action, and ejected smoothly and positively. Conveniently grouped controls, hydraulic steering, good visibility — such features as these keep operators fresh and at peak efficiency.

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NAME THE DATE...
YOUR DEALER
WILL DEMONSTRATE

SEVERAL large mining companies have reported to their stockholders that exploration for uranium is under way, but no discoveries have been made.

We have been somewhat perplexed by these discouraging reports from seemingly experienced operators, but the May 23 issue of *Life* brought clarification. On pages 25 through 35 the real lowdown on making millions in uranium is revealed. Using engineering logic, the article covers each phase of prospecting in proper order, listing necessary equipment: what to look for—such as carnotite, uraninite, and pitchblende—where to look, how to look, and how to recognize the geology of uranium deposits. *The Shinarump formation is 175 million years old.*

The trouble with professional uranium seekers and mining companies has been the approach, because any fool knows (according to this article) that you must have a four-wheel drive jeep, $1685; army surplus knapsack, $3; ore sample sacks, 25¢ each; green-topped scintillation counter, $647, *a special instrument for finding green-topped orebodies that emits green "scints" sometimes called "scents"*; assay kit, $12.50, *no prospector is complete without one;* black Geiger counter, $350, *counts only black "geigers," but an unpainted one is cheaper and you can choose your color;* map portfolio, *keep well filled with road maps, street maps, airline routes, etc.;* 100-ft and 1500-ft chains, making only two measurements necessary; and miscellaneous items like camping equipment. Also, a pad of claim notices (25¢ for a pad of 100) is most valuable. Some of the bigger prospectors take a secretary along to fill out the notices correctly.

Some of the pros have managed to pick up a few of these items, but the real secret is in the clothing. First of all, the companies must recognize that the geologist must take his entire family. Each member of the team must be dressed in "uranium finders" suits such as the "Diggerette, Jr.," for the youngster; the "U-235" for mother; and a navy-blue smock with red pockets for father, which should be worn in conjunction with a red hat and built-in earphones. *We think the earphones are connected directly with Radio Beacon station for up-to-date weather reports.* It is rumored that a new lead-lined outfit is coming out to prevent radiation sickness for all overexposed geologists.

With only eight pictures (excellent photography), the minerals sought are laid before the reader. It is inconceivable that trained men have stumbled around so blindly and continue to peer at rocks that do not even look like these. Absolutely amazing! There are not very many uranium minerals and all are obviously blue-black-brown-tan-red in color and have a soft-hard texture.

And where to look? Simple. Likely areas are limited to the northern half of Canada, the western half of the U. S., and some areas in the East. (Ed. Note: There are stories coming out of Africa and Australia that would lead you to believe that uranium is being found there, too.) But when looking, remember the old prospectors' maxim, "Gold is where you find it."

Of course, we feel sure that the editors of *Life* gave this material to the reading public with tongue in cheek; nevertheless it is the most humorous semi-technical presentation in the lay press for many a year. A profound conclusion reported by the editors will no doubt be quoted often by the mineral industry, "What was rock five years ago is ore now. Who knows what rock today will be ore tomorrow? Indeed, who knows what ore today will be rock tomorrow?"

An array of the counters, plain and fancy, that the prospective uranium prospector has to choose from—if he follows *Life's* guidance.

Actually, the sad thing is that this article and thousands like it printed before have turned a serious unhumorous business of finding a strategic metal into a hobby equivalent to color photography or skin-diving. The basic cause of this has been the unintelligent approach to security regulations. The information released has only tantalized the public and created a mass hysteria, but there has never been enough data for a technical publication really to sink its teeth in.

C. M. Cooley

A Milestone in the Progress of Extractive Metallurgy —

Oxygen Flash Smelting Process Swings Into Commercial Operation

by the Staff,
Mining & Smelting Div.,
International Nickel Co. of Canada Ltd.

CONCENTRATES at the rate of 1000 tons a day are being smelted by International Nickel Co.'s new commercial flash smelting furnace. Developed by Inco, the process is a radical departure from the former practice which involved conventional smelting in coal-fired reverberatory furnaces.

In the new process copper flotation concentrate and flux are injected horizontally with oxygen into a specially designed reverberatory furnace, and smelting temperature is maintained solely by the flash combustion of iron and sulphur while the particles are in suspension. The major benefits of this new process stem from two sources: 1)—Substitution of energy from local resources for imported coal; and 2)—Production of liquid sulphur dioxide, replacing equivalent imported sulphur. A measure of these benefits is afforded by considering the saving, in 1954, of 60,000 tons of coal and the production of 70,000 tons of liquid sulphur dioxide, equivalent to 35,000 tons of sulphur.

1000-Ton Flash Smelting Furnace

When laboratory and pilot plant investigations showed that autogeneous oxygen smelting of fine sulphides was commercially feasible, a commercial furnace treating 500 tons of sulphides was started in January 1952. The second commercial flash smelting furnace, rated at 1000 tons of concentrate per day, began production in December 1953, and the 500 ton furnace became a standby unit.

The 1000-ton furnace, similar in design to the 500-ton unit, is 68 ft long, 24 ft wide, and 17 ft high at the ends, outside the steel casing. The uptake, with center line 27 ft from the slag end, is the full width of the furnace, 11½ ft long, and rises 22 ft above the furnace roof. The settling chamber is 60 ft long, 16 ft wide and 23 ft high. Matte is tapped through the side of the furnace about 13 ft from the slag end. Roof and side walls are chrome magnesite and bottom magnestite brick. Among the important advantages already noted for the larger combustion chamber are the marked decrease in brick erosion formerly caused by impingement of molten particles on the roof and side walls, and improved separation of matte and slag. The furnace has smelted up to 1200 tons of concentrates or 1450 tons of dry solid charge in 24 hr.

Oxygen at about 23 psig flows to the furnace through a 16-in., insulated, steam-traced line. Pressure is reduced to 17 psig for distribution through the 8-in. branch lines and automatically regulated valves to each burner.

As in conventional furnaces, refractory life is affected by initial heating rates. A satisfactory practice for this furnace entails preheating to 400°F in one day with a wood fire, then to 2200°F in four days by oil heating. Oil-firing is continued for a fifth day at 2200°F, while the roof is thoroughly grouted with a mixture of fine magnesite dust and basic cement. Roof cover plates are then set in place, bolted together and bolted to the furnace shell to form a gas-tight unit.

The oil burners are then removed and the sulphide burners inserted. The burners are started singly by turning on the oxygen to full volume before starting the feed conveyors and feeders, whereupon smelting commences immediately. The operation is quiet. The smelting action appears as a fog formed by sulphides burning in suspension.

To insure smooth, continuous operation, furnace temperatures, controlled by the oxygen to sulphide

North end of the new flash smelting furnace shows the slag tapping platform beneath the burner platform. The slag hole is kept beneath the surface of the slag in order to maintain a gas seal. Oxygen at about 23 psig flows to the furnace through a 16-in. insulated, steam traced line.

ratio, are continually recorded by thermocouples and radiation pyrometers. Slag and matte temperatures are observed regularly with an optical pyrometer. Temperature in the uptake averages about 2300°F, the slag 2250°F, and the matte 2150°F.

Skimming and tapping offer no unusual problems. Matte contains about 45 pct CuNi, and is blown to blister copper in Pierce-Smith converters. The converter slag is treated in the converters and reverberatory furnaces of the nickel circuit. The furnace slag is continuously cleaned by burning pyrrhotite concentrate, low in copper and nickel, in small burners at the slag end, as described under Laboratory and Pilot Plant Investigations.

The gases leaving the furnace are oxygen-free and normally average about 75 pct SO_2, the balance being essentially nitrogen. Gas-borne dust is recovered in the settling chamber and the gas cleaning system. Except for a splash tower at each settling chamber outlet, the same gas cleaning system serves both furnaces.

Furnace Charge Drying

Thorough drying of all solids fed to the furnace is essential for satisfactory operation of the feed system. To this end, three completely separate air-borne systems are used for drying and conveying copper and pyrrhotite concentrates and flux. The copper drying system, with a capacity of up to 54 tons of concentrate per hr, using three 4-ft diam x 18-ft long drum dryers. The product is recovered by dry cyclones, and the gas is finally cleaned by wet cyclones. The dryers are fired with pulverized coal, and the exit gas temperature is maintained at 400°F. Similar drying systems are used for sand and pyrrhotite except for the absence of a wet recovery section. Here, the discharge from the fans enters the large copper converter settling chamber for dust recovery.

Feeders and Burners

Furnace feeding, essentially automatic and centrally controlled, is based on the use of gravimetric belt and rotary feeders. The gravimetric feeders maintain a constant weight of material on a weigh belt and changes in feed rate are obtained by varying the belt speed. Rotary feeders, controlled by the speed of the weigh belt, supply the gravimetric feeders and prevent flooding from the bins. The concentrates and sand, thus properly proportioned, are mixed and fed by a screw conveyor to constant speed rotary air locks above each burner which serve as seals.

The importance of burner design, spacing, and alignment must be emphasized. Present burner design provides for entry of the dry solids into the oxygen stream through a pipe extending into the burner. Oxygen enters the burner through a pipe with swivel joints and injects the solids into the furnace. Water jackets, surrounding the burner to avoid ignition and burning of the tip by the oxygen stream, are made of steel tubing, inserted through a stainless steel sleeve set in the furnace wall and extend slightly beyond the inside face of the wall to minimize slagging over. Too high an oxygen velocity may cause excessive turbulence and fluxing

or erosion of the refractories. Too low a velocity can cause dribbling and plugging of burner tips, or pile-up of feed in the furnace below the burners.

Gas Cleaning System

Production of liquid sulphur dioxide from the furnace gas imposes a major gas cleaning and cooling problem rarely encountered in metallurgical operations, since a 75 pct SO_2 gas must be cooled through about 2200°F and cleaned to less than 0.003 grains of dust per cu ft. This is accomplished in three major steps, comprising: 1)—mechanical settling of dust and gas cooling by passage through a large, uninsulated, air-cooled settling chamber, 2)—countercurrent water scrubbing to clean and cool the gas to about 80°F without excessive loss of SO_2 to the scrubber water, and 3)—final treatment through a wet electrostatic precipitator for SO_3 removal.

The dust-laden gases enter the settling chamber at about 2300°F. Here, a large part of the dust settles and the gas temperature drops to about 1200°F before entering the wet system. The gas flows through a water spray tower which is 4 ft diam and 17 ft high, the sludge from which drains to a 10-ft diam settling cone. The cone overflow recirculates to the splash tower while cone underflow slurry is treated with lime to neutralize acid. The solids are recovered as filter cake.

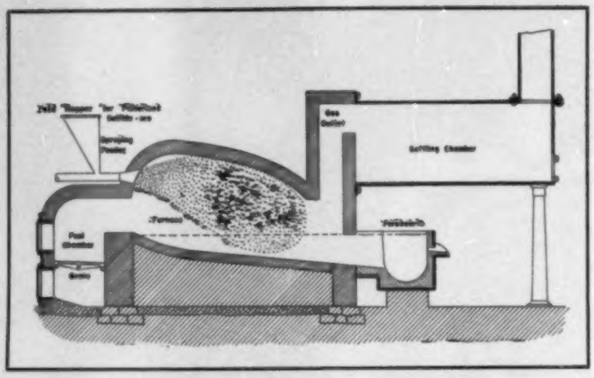
Table I. Heat Evolved in Flash Smelting Process at 1250°C

Constituent	Kcal	Pct
Matte	68	—
Slag	53	50
SO_2	38	16
Radiation loss	82	34
Total	241	100

The water-saturated gas passes through three Venturi scrubbers in series, engineered by Singmaster & Breyer, New York City. The spray water flows countercurrent to the gas through the scrubbing system and is cooled in heat exchangers between each of the three stages. Final gas cleaning is by a wet Cottrell precipitator for removal of residual SO_3 fume. The gas cleaning system is served by a 3600 rpm, 200 hp centrifugal fan rated at 4000 cfm at 115-in. W.G. at 105°F.

Corrosion by the strong, wet sulphur dioxide gas containing small amounts of SO_3, and by the SO_2 saturated solutions, is an ever-present problem. However, type 316 stainless steel and lead provide satisfactory resistance. The splash tower, scrubbers, cyclones, fans, circulating water pumps and discharge piping, heat exchanger tubes, and all ductwork are of stainless steel, while the settling cone, standpipe, Cottrell precipitator and return water lines are of lead. The 16-in. diam 1500-ft line delivering the cleaned gas to C.I.L. is also of stainless steel.

The cleaned gas is dried with sulphuric acid, then compressed and cooled to condense sulphur dioxide. The liquid is drawn off to storage and the remaining gas is further compressed and cooled to liquefy more sulphur dioxide. Following the second condensation, the tail gas is sent to the sulphuric acid plant.



This flash smelting furnace diagram proposed by Bridgman is reproduced from U. S. Patent 578,912 dated Mar. 16, 1897.

The entire operation is centrally controlled. Each burner is controlled by three instruments, two indicating, recording, and totaling concentrate and sand feed, the other, recording and totaling oxygen flow. Any one of eight abnormal conditions will shut off the oxygen and feed to all burners.

Furnace draft is regulated by a butterfly valve between the fan and the Cottrell, actuated by a recording controller. The furnace is operated at low draft to minimize air infiltration. Draft losses at various stages in the gas cleaning system are shown by a series of gages used to indicate build-up of sludge at any point.

Temperatures are recorded by pyrometers in the roof of the furnace and the sidewall of the uptake. Furnace temperature is controlled by minor adjustment of oxygen flow rate. Temperatures at specific locations in the roof, bottom and side walls of the furnace and temperatures of the gas and circulating water in the gas cleaning system are measured by a 36-point indicating pyrometer.

The furnace exhaust system has three outlets as follows:

1)—16-in. line to the C.I.L. liquefaction and acid plant.

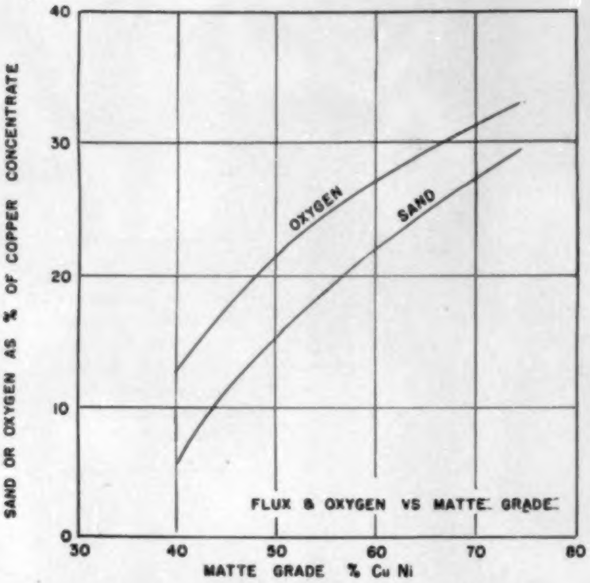
2)—Bypass to the converter flue from the delivery line situated between the furnace scrubber system and the C.I.L. plant. The bypass automatically opens if abnormal delivery pressure develops in the line.

3)—Bell damper arrangement from the settling chamber to the converter flue. The damper is operated from the control room and is used to bypass the furnace gases during periods of cleaning or repairs to the scrubbing system or when the furnace is being heated.

The volume of gas to C.I.L. is measured by a totalizing flowmeter and the SO_2 content is continuously recorded.

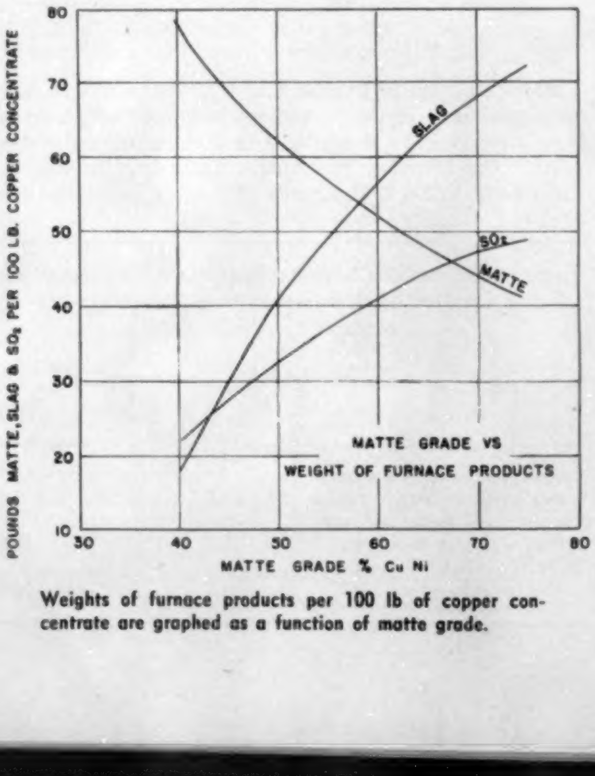
Oxygen Plant

The Copper Cliff L'Air Liquide Oxyton oxygen plant, third largest in the world, produces 325 tons per day of 95 pct oxygen, corresponding to 2 2/3 billion cu ft of oxygen per year or three times the production of all the cylinder oxygen plants in Canada. The Oxyton commenced production in January 1952, and has given excellent performance. Since temperatures as low as −300°F are involved, embrittling most ferrous metals, certain parts of the plant were made from a special Inco-developed 8.5 pct nickel steel.



Oxygen requirement as percent of copper concentrate for given matte grades and sand required as percent of copper concentrate to produce various matte grades and 35 pct SiO_2 slag are shown.

Oxygen plant operation is automatic once the liquefaction process has been started. Control and metering are carried out by some 40 centralized control instruments. About 30,000 scfm of air is compressed to 68 psig in a turboblower, water-scrubbed, and sent through reversing regenerators where the carbon dioxide and water are frozen out. The resulting cold air, near its dew point, is then passed directly to a high pressure rectification column. Necessary refrigeration is supplied by expanding some of the gas through a turbo-expander, simultaneously generating power. Rectification of the liquid air is effected in three columns working at 5, 2.5 and 1.2 atm absolute respectively, thereby effecting separation of oxygen from nitrogen. The gaseous oxygen produced is then carried 6000 ft in a 16-in. diam elevated pipeline to the oxygen flash smelting furnace.

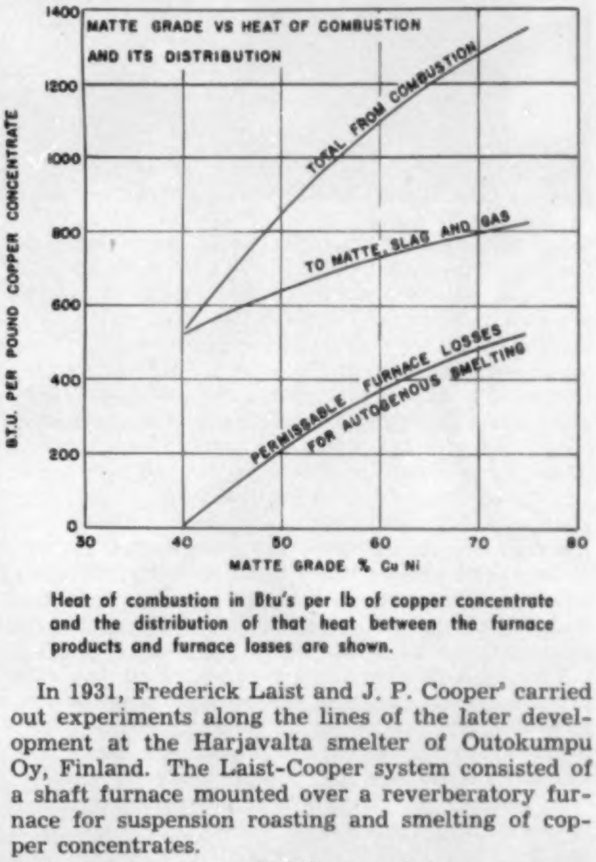


Weights of furnace products per 100 lb of copper concentrate are graphed as a function of matte grade.

No storage facilities are provided but the demand for oxygen at the flash smelting furnace is relatively constant. The pressure in the pipeline to the furnace is controlled at 25 psig and excess oxygen is bypassed.

History of Process

There have been numerous proposals during the past half-century for smelting fine sulphide ores in suspension but, until recently, none of these plans for flash smelting has been commercially successful. In 1897, H. L. Bridgman,[1] with remarkable prescience suggested the reverberatory furnace shown on page 536 for flash smelting of sulphide ores "by means of the heat generated by their own combustion" and by feeding the ore "as a spray of dust into the . . . strongly oxidizing atmosphere of a furnace chamber." J. H. Klepinger, M. W. Krejci, and C. R. Kuzell[2] recommended the use of preheated air in the process.



Heat of combustion in Btu's per lb of copper concentrate and the distribution of that heat between the furnace products and furnace losses are shown.

In 1931, Frederick Laist and J. P. Cooper[3] carried out experiments along the lines of the later development at the Harjavalta smelter of Outokumpu Oy, Finland. The Laist-Cooper system consisted of a shaft furnace mounted over a reverberatory furnace for suspension roasting and smelting of copper concentrates.

Norman[4] recommended the use of oxygen or oxygen-enriched air for autogenous flash smelting of copper and copper-nickel concentrates. His calculations indicated that oxygen flash smelting could be economically attractive.

A number of others, including Chase, Freeman, Vanyukov, Zeisberg, and Haglund,[5,6,7,8,9] have described related procedures, including the use of oxygen or oxygen-enriched air for roasting and production of sulphur dioxide, the use of auxiliary oil burners, and the use of oxygen or oxygen-enriched air to produce molten iron oxides from pyrite.

In the past decade autogenous flash smelting was independently developed both at the Copper Cliff smelter of the International Nickel Co. of Canada Ltd.[10,11] and at the Harjavalta smelter of Outokumpu Oy, Finland.[12,13] In the former operation

Control room for the 1000-ton flash smelting furnace contains instruments for controlling and recording pertinent data of the furnace operation.

oxygen is used to smelt the sulphides whereas in the latter the combustion air is preheated by heat exchange with the exit gases. Inco began mini-plant tests on oxygen flash smelting in 1945, pilot plant studies in January 1947, and commercial operation on an autogenous basis in January 1952. The Outokumpu Oy started pilot plant studies in February 1947, and semiautogenous commercial operations in 1949. The processes meet the economic requirements of their respective localities. In Finland hydroelectric power cost, following annexation of territory by the USSR, is too high to permit production of low cost oxygen and there is a good market for sulphuric acid. On the other hand, Inco hydroelectric power cost in northern Ontario permits production of low cost oxygen and there is a good market for liquid sulphur dioxide.

Two essentials in the development of the Inco process, low cost oxygen and conversion of the furnace exhaust gas to liquid sulphur dioxide, were provided by the Canadian Liquid Air Co.[14,15] and Canadian Industries Ltd.,[16] respectively.

In general, the oxygen flash smelting process involves drying the sulphide concentrates, and flux, and injecting them with oxygen into the smelting furnace to produce matte, slag, and a gas containing about 75 pct SO_2. The gas is water-scrubbed and treated by a wet Cottrell before delivery to the Canadian Industries' plant. Production of liquid sulphur dioxide involves drying, compressing and cooling the cleaned gas. The liquid sulphur dioxide is used almost entirely in the preparation of cooking acid by sulphite pulp mills within a radius of 400 miles of Copper Cliff. Such use of liquid sulphur dioxide, in place of sulphur burning, has proven most satisfactory.[17]

Thermal Considerations

In the furnace, the oxygen combines with some of the sulphur and iron of the chalcopyrite $CuFeS_2$, to form SO_2 and FeO. The heat from FeO formation almost equals that obtained by sulphur oxidation. The primary matte contains about 50 pct copper, approximating $Cu_2S \cdot FeS$, but is diluted to a lower copper content when pyrrhotite is burned for slag cleaning. This novel method of cleaning the copper-rich slag by flash smelting pyrrhotite at the skimming end of the furnace is an important feature of the Inco process. Siliceous flux is used for slag formation. Principal reactions may be expressed as follows:

$$2\,CuFeS_2 + 2\tfrac{1}{2}\,O_2 \rightarrow Cu_2S \cdot FeS + 2\,SO_2 + FeO \qquad -\Delta H_{298} = 179 \text{ kcal} \qquad [1]$$

$$FeS + 0.75\,O_2 \rightarrow 0.5\,FeS + 0.5\,FeO + 0.5\,SO_2 \qquad -\Delta H_{298} = 56 \text{ kcal} \qquad [2]$$

$$1.5\,FeO + 0.75\,SiO_2 \rightarrow 0.75\,(2\,FeO \cdot SiO_2) \qquad -\Delta H_{298} = 6 \text{ kcal} \qquad [3]$$

$$Cu_2O + FeS \rightarrow Cu_2S + FeO \qquad [4]$$

Some copper is oxidized and is dissolved in the slag, probably as Cu_2O, and some copper sulphide is both dissolved in the slag and suspended as matte prills. On burning pyrrhotite according to Eq. 2, the matte prills and dissolved copper sulphide are

Table II. Comparison Between Pilot Plant Flash Smelting and Conventional Reverberatory Smelting, Pct

Item	Matte CuNi	Slag CuNi	Slag SiO_2
Copper concentrate and sand flux, without slag cleaning	57.7	0.74	34.4
Copper concentrate and sand flux, with slag cleaning	57.2	0.48	35.9
Standard coal-fired reverberatory furnaces—April 1947	44.3	0.70	36.9

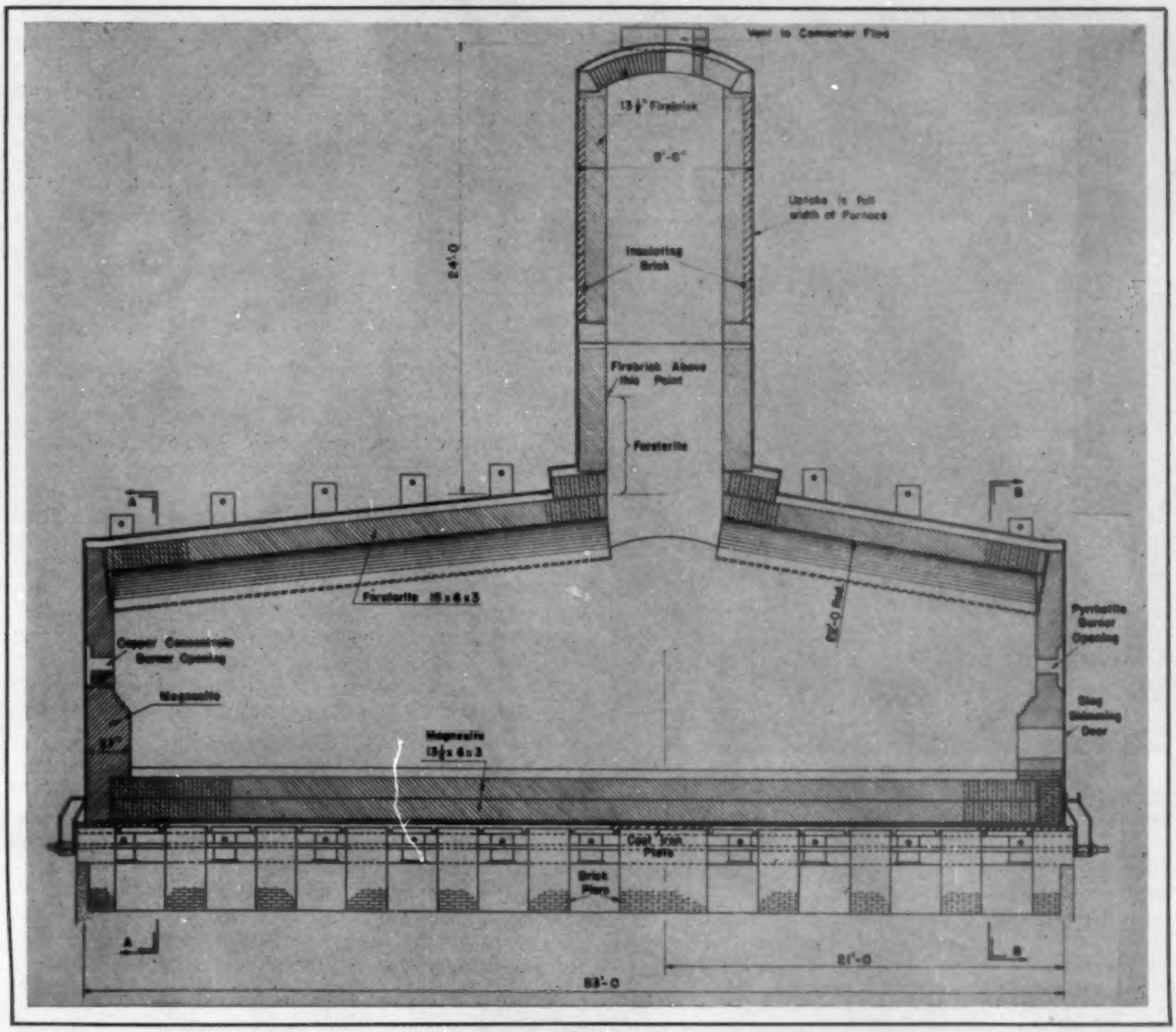
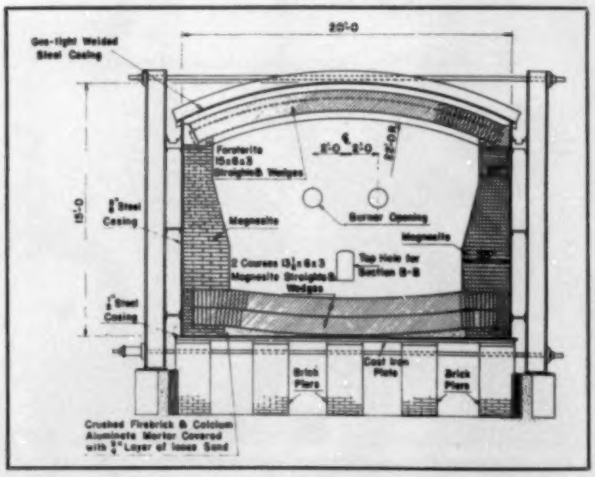


Diagram of first commercial flash smelting shows construction details. Furnace was started up in January 1952 and treated 500 tons of sulphides per day.

washed from the slag by molten iron sulphide droplets, and the oxidized copper is reduced according Eq. 4, resulting in a slag lower in copper. Since relatively little copper oxide is involved in this reduction, its effect on the overall heat balance is negligible.

The total heat evolved in smelting chalcopyrite and burning pyrrhotite as depicted by Eqs. 1, 2, and 3 is 241 kcal, see Table I.

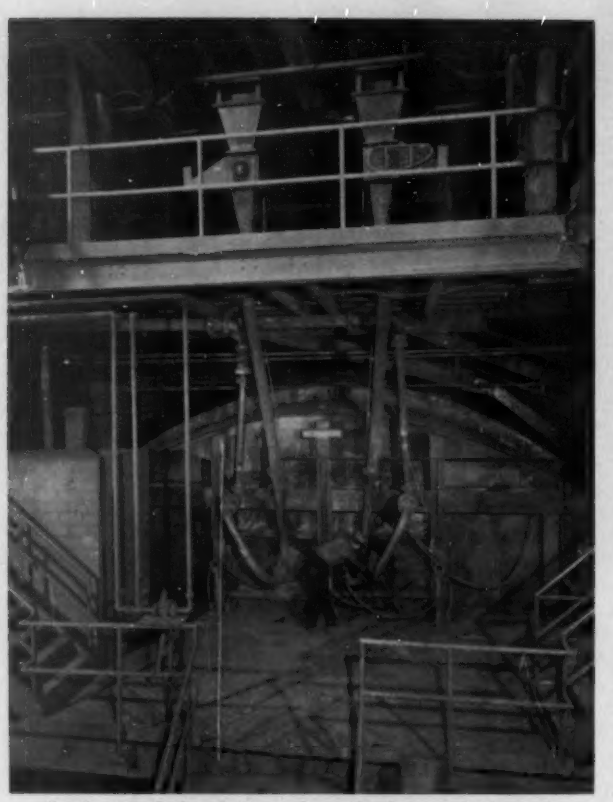


Section A-A' through flash smelting furnace shows the gas-tight welded steel casing which encloses the furnace.

Laboratory and Pilot Plant Investigations

Mini-plant tests on autogenous smelting of sulphides with oxygen were conducted in the Copper Cliff laboratories, using a horizontal gas-tight furnace, 12x15x48 in., fitted with an injection-type burner. This furnace smelted up to 3 tons of concentrate per day and produced 98 pct SO_2 gas. The matte contained about 52 pct Cu and the slag 0.45 pct Cu. With these encouraging results, and with the prospects of obtaining low cost oxygen and markets for the sulphur products, a pilot plant investigation was undertaken.

The pilot plant was designed to smelt 20 tons per day of sulphide concentrates with oxygen (95 to 99 pct O_2) from a 5-ton per day plant. The furnace, initially 8x2x2½ ft high inside, consisted of gas-tight welded steel shell with insulation between the shell and the refractory lining. The furnace and dust settling chamber were modified several times, and various refractories and methods of insulation were tried. The final pilot plant furnace measured 15x4x4 ft high at the skewbacks and had a capacity of about 25 tons of concentrates per day. Refractories that gave satisfactory service were forsterite



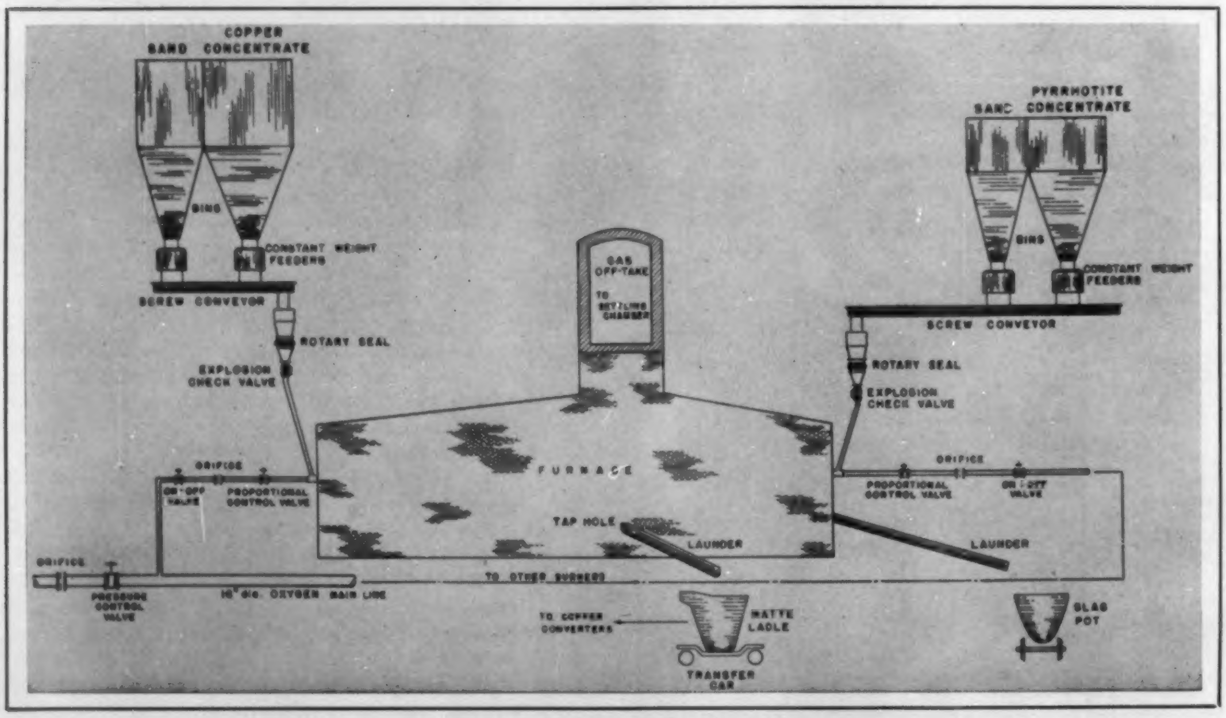
South end of the platform shows the burner platform of the 1000-ton flash smelting furnace. Feed pipes extend from the burners up to the rotary air locks above and up to the gravimetric feeders on the upper floor.

roof and magnesite walls and bottom. The furnace was preheated with oil but thereafter operation was autogenous by burning of the sulphides with oxygen. Temperatures were measured by optical pyrometer as thermocouple wells were attacked.

Mini-plant operation had demonstrated the necessity of a dry, properly proportioned, and uniformly fed charge. To provide for such conditions in the pilot plant, sulphide concentrates and flux were dried, ground, and transferred to separate bins at the furnace. Feed from each bin was then controlled by an integrating gravimetric belt-type feeder and conveyed to a mixing and sealing feeder discharging to the burner. Oxygen, delivered to the burner at 10 psig, injected the solids into the furnace.

Skimming and tapping offered no unusual problems but gas cleaning prior to delivery to the Canadian Industries Ltd. liquefaction pilot plant required considerable development. Slag was skimmed from the end of the furnace opposite the burner, and matte was tapped either from the same location or from the side of the furnace. After considerable revision, gas was cleaned by passage through a settling chamber, a water spray scrubber, a wet cyclone, and a baghouse equipped with fiberglass bags. Draft for the gas recovery system was supplied by a high-speed fan which delivered the cleaned sulphur dioxide gas under pressure to the Canadian Industries Ltd. liquefaction pilot plant. A Leeds & Northrup sulphur dioxide analyzer-recorder was connected through a drier and filter to the blower outlet. When using oxygen of 95 pct purity, the furnace gases contained 80 to 90 pct SO_2, the balance being mainly nitrogen.

The pilot plant operated for about two years and treated over 7000 tons of concentrates. Most of this time was spent on flash smelting of regular copper and nickel concentrates. Some of the specific items tested were as follows: 1)—Use of sand or quartzite flux with lime and other slag-modifying agents; 2)—Slag cleaning with pyrrhotite concentrate; 3)—Addition of converter slag to the furnace; and 4)—the smelting of higher grade sulphide concentrates to produce higher grade mattes, white metal, and metallic copper. Various injection burners were used,



During one month the daily furnace charge averaged 520 tons of copper concentrate, 97 tons of pyrrhotite concentrate, and 87 tons of sand flux. Oxygen averaged 128 tons per day or 20.8 pct of the sulphides treated.

Table III. Pilot Plant Data With No Pyrrhotite Used For Slag Cleaning

Item	Data
Assay of copper concentrate	
CuNi	31.5 pct
Fe	30.7 pct
S	33.3 pct
SiO_2	1.9 pct
Slag produced, SiO_2	35.0 pct
Sand flux, SiO_2	79.0 pct
Feed temperature	50°F
Matte temperature	2050°F
Slag and gas temperature	2250°F

and the oxygen purity was varied between 95 and 99.5 pct.

Slag losses from both nickel and copper concentrates were lower than those of conventional reverberatory practice in spite of higher matte grades and such losses were substantially decreased by flash smelting pyrrhotite concentrate in the furnace before skimming. Typical results for copper are shown in Table II.

The results of the pilot plant campaign fully confirmed the indications from the mini-plant studies that the oxygen flash smelting process was sound, and demonstrated that, under appropriate conditions, sulphide concentrates containing over 15 pct S could be flash-smelted autogenously with oxygen more economically than by normal reverberatory practice.

Pilot plant data used for the design of the first commercial furnace are shown in the figures on page 537. These apply for the conditions shown in Table III when no pyrrhotite is used for slag cleaning. In the commercial operation, using pyrrhotite, matte grades are lower.

First Commercial Furnace

Immediately following completion of the pilot plant investigations in 1949, work began on a commercial furnace to treat 500 tons of sulphides per day. However, slow deliveries delayed start-up until January 1952. The furnace is shown on page 539. A short cross flue, not shown, connects the uptake to a settling chamber. The upper sections of the furnace walls and uptake were tied to the furnace shell with steel strips imbedded in the brick joints. An opening in the roof of the uptake was used to vent furnace gases when heating with oil or to bypass the gas cleaning system when maintenance was required.

The settling chamber, of welded steel plate, was 40 ft long, 16 ft wide, and 17½ ft high. The cross flue from the furnace uptake and the walls and roof of the settling chamber directly opposite the uptake were lined with firebrick. Fins were welded to the outside of the walls and roof and were covered to form ducts through which air was blown to increase gas cooling before scrubbing and to cool the steel plate. Two parallel hoppers at the bottom of the settling chamber collected the flue dust and discharged it by a screw conveyor through air locks to conveyors and thence to the sand dryer for retreatment.

Although initially there was considerable difficulty with such items as feeders and gas-cleaning equipment, the technical and economic success of the project was never in doubt. During one month the daily furnace charge averaged 520 tons of copper concentrate, 97 tons of pyrrhotite concentrate, and 87 tons of sand flux. Oxygen averaged 128 tons per day or 20.8 pct of the sulphides treated. Daily production, excluding flue dust and slimes, averaged 310 tons of matte containing 45.4 pct CuNi and 284 tons of slag containing 38 pct SiO_2 and 0.76 pct CuNi. Gases leaving the furnace carried about 100 tons of SO_2 per day.

High smelting rates were responsible for rather severe refractory attack, the strongest attack being on the side walls above the slag line, especially below the uptake. Deterioration of the roof was greatest near the uptake, and the uptake arches were also fluxed and eroded. There was, however, no noticeable attack on the furnace bottom. To decrease flame erosion of the roof and side walls, the original furnace was modified to provide a sloping roof with a rise of approximately 3 ft from the ends of the furnace to the bottom of the uptake, and the burners at each end of the furnace were brought 1 ft closer together. Heat loss from the furnace was also increased by removing the insulation between the refractory brick and the steel shell, by welding fins to the furnace shell at 10 in. centers, and by inserting copper water jackets in the refractory lining of the furnace in the uptake area. The rate of fluxing of magnesite and forsterite brick by oxides increases rapidly above 2450°F and constant care was required to avoid high flame temperatures. Heat distribution in the 500-ton furnace is given in Table IV.

Table IV. Heat Distribution in the 500 Ton Furnace, Pct

Heat to the matte and slag	57
Heat radiated from furnace walls, roof, and uptake including water jackets	26
Heat radiated from settling chamber, including flue dust	9
Heat removed by heat exchangers in gas cleaning	7
Heat in gases to C.I.L. saturated 100°F	1
	100

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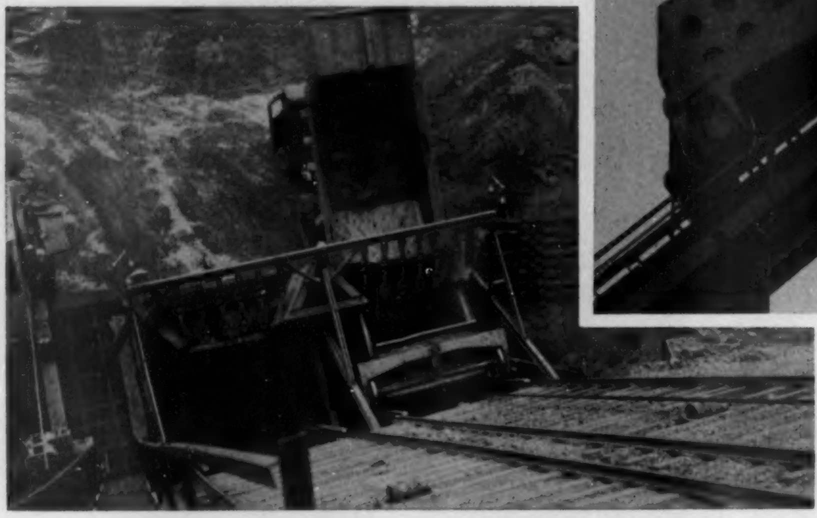
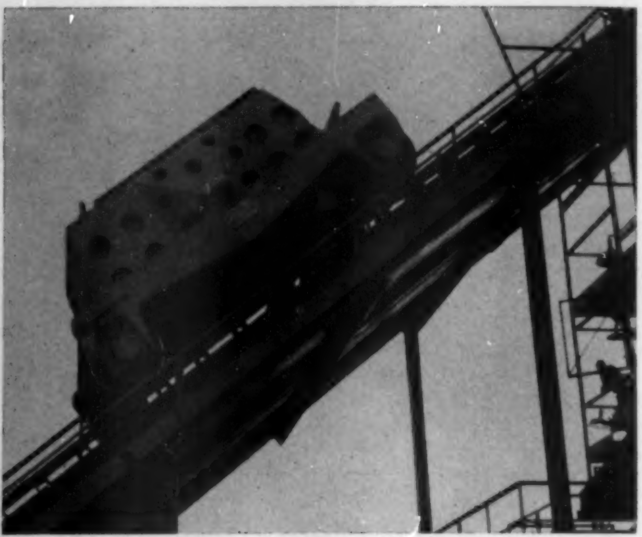
Open Pit Forum

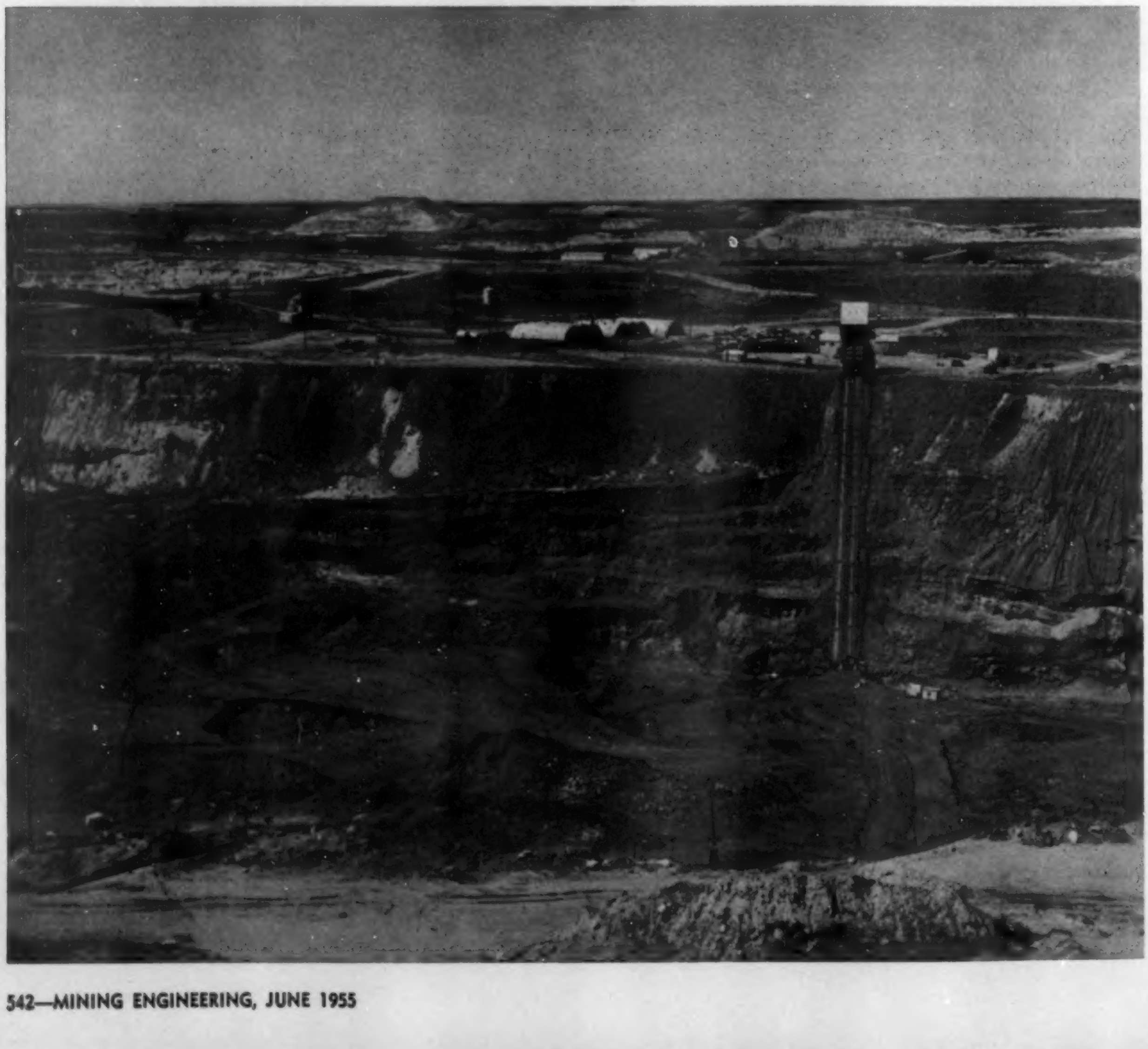
Inclined Skip Haulage





LEFT—Truck dumping into all-welded skip. The system is designed to accommodate a full truck load and will handle any size material that a shovel can load. ABOVE—The skip is box-type construction of Man-Ten steel. Double walls are used on the box for free air passage in the event winter heating is required.

Typical Mesabi Range installation of the Rockover type skip showing dumping area, as well as permanent dumping and screening plant on the pit rim. Skips travel on the incline at ab out 1000 fpm. In deep pits, 1500 to 2000 fpm would be feasible.



Skip System Simplifies Costly Problems of Elevating Ore From Open Pit Mines

by J. S. Seawright

HAULAGE is a costly feature in the operation of an open pit mine, whether it be iron, copper, or limestone. The National Iron Co. has adapted an old underground method to the open pit inclined skip haulage to bring the ore from the pit bottom to the crusher or beneficiation plant. The Rockover skip has been placed in operation where limited areas have retarded or eliminated use of long rail or road slopes. Deep and narrow orebodies subject to rapid increase in depth that discourage use of conveyor belts and necessary crushing plants are ideal for this system.

The skip haulage method was developed to combine the desirable features of conveyor, truck, and rail haulage and at the same time avoid the drawbacks. The skip was designed to follow the natural angle of repose of the pit wall and can vary from 25° to 45°. Open-pit skips now in operation show that the installation is successful and provide the operator with a short, level haul for trucks, low maintenance, and investment with high flexibility.

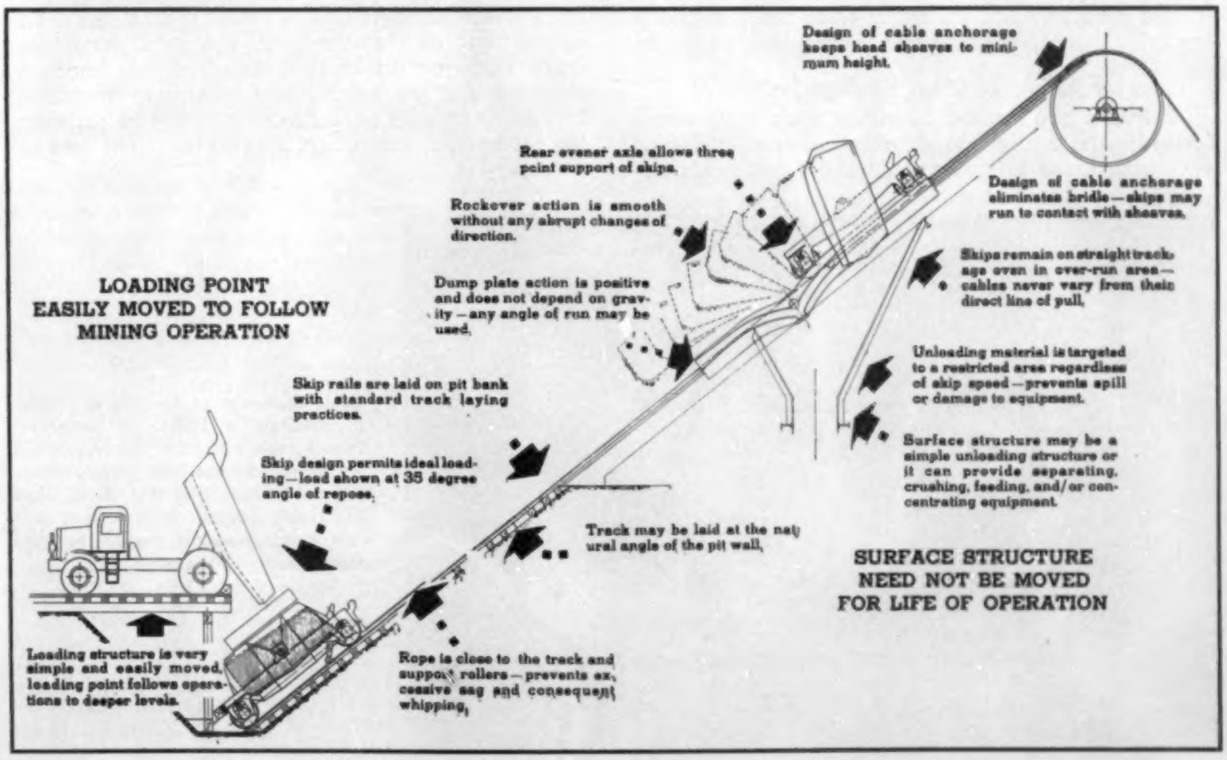
J. S. SEAWRIGHT is Sales Manager for the National Iron Co., Duluth.

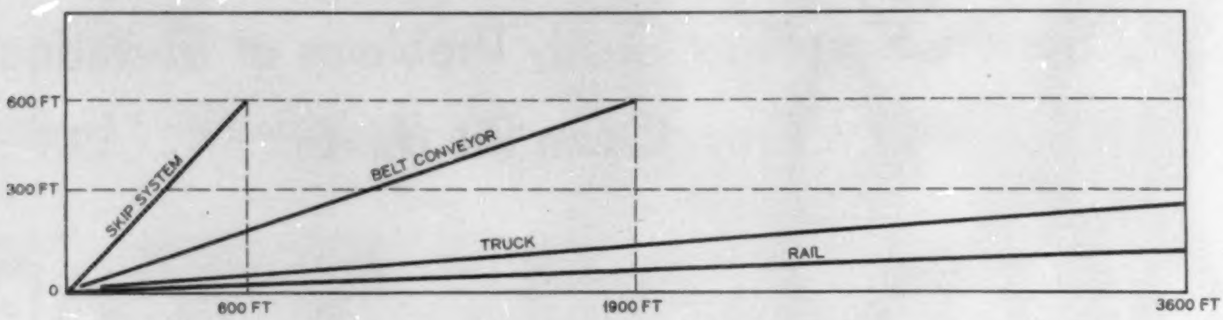
The initial reaction of combining open pit and underground methods was mixed. It seemed that application of skips was a step backward from the high tonnage methods of the open-cut mine. But the open-pit skip is designed upon the premise that one truck fills the box—a 34-ton skip is used in conjunction with 34-ton trucks. It is only a matter of cycling the trucks for dumping when the empty skip is positioned for loading.

Four Units in Operation

The first mine to make use of this new approach to haulage was the South Agnew mine at Hibbing, Minn. Operated by the South Agnew Mining Co., a 20-ton installation was constructed to simplify handling. The Schley mine of Jones & Laughlin Steel Corp. is using a 15-ton system, with a third unit in operation at Snyder Mining Co.'s Whiteside mine. The M. A. Hanna Co. placed a 34-ton rig in its Morton mine at Hibbing.

Installations made to date have used balanced, two-skip systems to handle 1000 LT per hr. At the moment the dumping skip is in the discharge position the lower skip is in the loading spot. The positive, smooth dumping action minimizes maintenance on boxes and frames.





Comparison of horizontal distances required for given amount of elevation by various open-pit haulage methods.

It has been the practice with these installations to place the track upon the available pit wall with minor amounts of ballasting to level the area. Generally accepted track laying practices were used. The ties and rails were raised in sections and connected to a section below, then ballasted after all were in place. Truck dump area is a simple structure wide enough to accommodate two trucks side-by-side. The dumping stand is constructed for easy removal when skip track is extended down the pit wall.

Skip System Compatible with Mining Practices

The Rockover skip method can be coordinated with present mining method. Ore loaded is trucked and transported to the skip. No additional equipment is required and in many cases fewer trucks are used. Standby equipment is reduced, and it has been recommended that only one spare skip and axle assembly are necessary.

It was the goal of the designer to eliminate the need for material sizing in the pit. The skips were built to handle any material the trucks are capable of hauling. This means that the crushing and screening can be delayed until the ore reaches the surface. The plant can be permanently located and only provisions for moving the truck dump are necessary as the pit floor retreats. In many cases the headframe for skips can serve as a basis for the crusher house.

Limitations of Other Haulage Systems

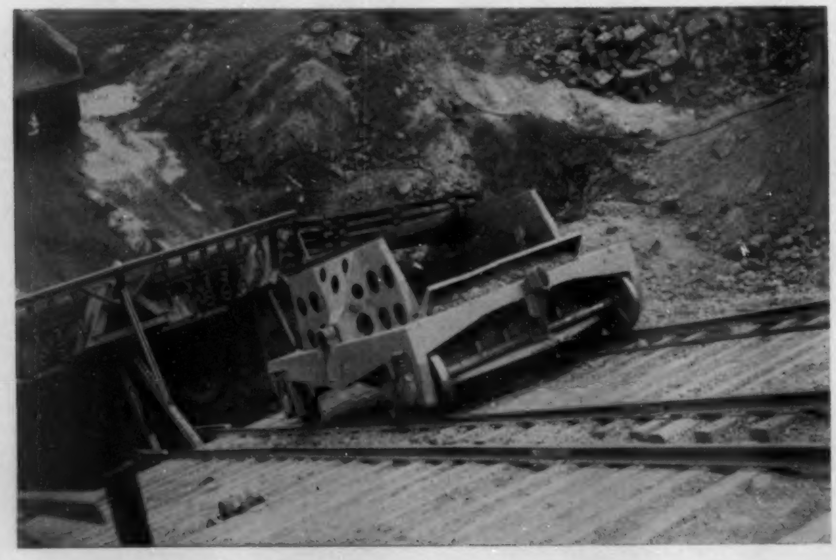
Railroads are limited to mines with large territorial limits to allow long, spiraling road beds and switching areas to stay within the 3 pct grade requirements. Initial investment and maintenance are costly.

Trucks are more widely used in open pit operations, but an 8 pct grade is the economical limit for truck haulage. Although trucks are operated on steeper grades, this usage is limited to short hauls. Investment in standby equipment is high, requiring up to one extra truck for each two in operation. Construction and maintenance of long haulage roads is a serious as well as expensive problem.

Crushing and screening equipment in the pit bottom is one of the principal difficulties with conveyor belt installations. In order that the ore can be unloaded in a position for flow through screening and crushing plants, it must be elevated by truck. As the pit bottom advances, the climb becomes even greater. Often it is necessary to move the screening plant because of unsatisfactory haulage conditions. This can be as costly as the original installation. Conveyors are limited to about 18° incline, which is also a factor in the cost.

Operating Advantages of the Skip System

The Rockover skip installations in operation were subjected to comparison by one company operating with trucks and conveyors in addition to skip systems. A cost analysis indicated that the skip gave the lowest operating cost per ton. It was also determined that like a conveyor, the skip gave short truck hauls on pit bottom, required less improved roadway for pit access, and minimum personnel. The inclined skip permitted flexibility in following the pit bottom down, and a crushing plant was not necessary in the pit.



Cable anchorage on the skip is designed to eliminate a bridle. It presents a smooth cable surface to the support rollers of the skipway and permits shorter over-run distances at the dump block. The cable support is such that it is only 4 in. above the top of the track, thereby reducing the cable whip.

Uranium Occurrences Of the Eastern United States

by Thomas N. Walthier

PROSPECTING for uranium in the East is hampered by the lack of bedrock exposure due to extensive overburden and residual soil. But, despite the problems of this physiographic province, it has not been ignored in the search for radioactive materials. Since 1951 both the U.S. Geological Survey and the Atomic Energy Commission have had field parties in the eastern U.S. Tempo of private prospecting is increasing, and many discoveries have resulted. AEC work so far has been concentrated in the areas of most numerous discoveries—Pennsylvania, New Jersey, and New York.

Accounts of uranium mineralization in the eastern U.S. are found in the old literature and one site in the Mauch Chunk area of Pennsylvania has been known since 1874. In 1949 McKeown[1] examined the original occurrence there and found another southeast of the town. The deposit appeared to have commercial possibilities and a short period of production began in July 1954.

A moderate amount of exploration work has been done in the East and a number of uranium occurrences have been found. None has yet proven to be economic although a few could be. The economic factor of distance to existing mills makes successful exploitation of an eastern deposit more difficult than for western ones.

The geology of the eastern United States is complex and includes rocks formed and altered by nearly every known geologic process. Mineralization has formed a variety of deposits and it was reasonable to expect that uranium, too, would be found in commercial amounts. After several years of search, it can be stated that uranium is present in many different rock types and that certain formations in given areas are more favorable.

A surprising number of deposits are associated with iron, either as magnetite-rich gneiss and schist, or as disseminated pyrite in sandstone. A trace of copper is found with one small sedimentary occurrence and minor galena occurs at another. Titaniferous magnetite in schist has auxiliary uranium in Pennsylvania. In some localities where iron oxide and iron sulphides are absent, the uranium minerals are found intergrown with biotite or hornblende. Uraniferous slag from a Revolutionary War iron furnace was found in southeast New York State. Slightly radioactive slag is also reported from Georgia and Alabama. The association of uranium and iron seems to be more than coincidental and a genetic relation is suggested.

Deposits in Sedimentary Rocks: An interesting occurrence of uranium is found on the north flank of Mt. Pisgah in a road cut on Pennsylvania Highway 29-209 immediately west of the town of Mauch Chunk, now called Jim Thorp, Pa. The property has been developed by the Lehigh Coal & Navigation Co. Basal Pennsylvania Pottsville formation, a highly siliceous dark gray quartz conglomerate, is exposed in the cut and holds the uranium. An irregular, but conspicuous, yellow coating of carnotite and other secondary uranium minerals is found for 2000 ft along the cut. Below the weathered surface carnotite disappears and a black uranium oxide, probably uraninite, occurs in its place. Detailed sampling shows that the uranium concentrations cut slightly across the bedding down dip, perhaps controlled by jointing. Along the strike the distribution is irregular, and the uranium-bearing material forms shoots rather than tabular sheets. In the main stope, a conspicuous fault forms the back and the long direction of the ore shoot is parallel to the slickensides.

In this same area, which borders the Pocono Plateau, five other uranium prospects are known. Four of these are found in artificial cuts, one is exposed along the bank of a steep valley, and all occur in fluviatile sandstone or graywacke of Upper Devonian age (Catskill formation). Small pods of uraniferous material characterize four of the prospects, but the fifth has possible commercial interest. In this one, the uranium is localized along the limbs near the crest of a small anticline. The mineralization is essentially parallel to the bedding, at least in the two dimensions now known. Discoverer Harry Klemic of the USGS reports that pyrite and galena have been identified in the more strongly radioactive portions. A wedge-shaped zone assays ore grade across mining widths for about 60 ft along strike. Where the uranium-bearing wedge is thickest, the dip carries the strata out of sight.

In the anthracite basins of eastern Pennsylvania, a considerable proportion of the carbonaceous shale lying on the coal mine dumps is feebly radioactive, but the best of this material that has been assayed runs no more than several thousandths of a percent U_3O_8. Even this minor amount in a large dump emits sufficient radiation to be recorded as an anomaly by a low-flying aircraft with a scintillation counter.

Based on the high percentage of mineralized road cuts and valley walls exposing these rocks, the sandstone beds below the Coal Measures, particularly the basal Pennsylvanian and Upper Devonian, appear to be favorable sites for uranium deposition. Hundreds of miles of similar beds are buried beneath 10 to 30 ft of overburden in eastern Pennsylvania. It is most improbable that the uranium concentrations are confined to the few places that the Pennsylvania Highway Dept. chose to excavate, or to the chance erosion of a river bank. Additional deposits probably exist.

The arkosic redbeds of the Stockton formation of Triassic age in southwest New Jersey and adjacent Pennsylvania contain small concentrations of torbernite and autunite in several places.[2,3] Abnormal radioactivity has also been found without any visible uranium minerals. All of the uraniferous material occurs in distinctly limonitic lenses of light gray arkosic sandstone. In one radioactive outcrop in a stream bed pyrite is moderately abundant. The limonite at the other occurrences presumably represents

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Geologic Environment*	Major Associated Metal	Number of Occurrences
Fluviatile sandstone	Fe (Pyrite)	12
Metasediment and gneiss	Fe (Magnetite)	11
Fault, shear zone	—	1 or 2

* Does not include monazite placers, uraniferous shales, and phosphates, or pegmatites.

weathered iron sulphides. Conformably overlying the Stockton arkose is the Lockatong argillite, also of Upper Triassic age. Black carbonaceous zones in the lacustrine facies are radioactive, but everywhere tested the grade is low and does not give hope of profitable extraction. Outcrops of the Triassic beds are exceptionally sparse except in a narrow belt along the Delaware River and their importance as carriers of uranium has not been ascertained.

Abnormal radioactivity, up to 15 times background was found last summer by Marcellus Stow of Washington and Lee University in Mississippian Price sandstone, southwest Virginia. Although not strongly radioactive, the readings are sufficiently high and widespread to warrant additional study. Great thicknesses of Mississippian and Pennsylvanian fluviatile sandstone in this part of Virginia and adjacent states deserve careful examination.

Deposits in Crystalline Rocks: Uranium, usually as uraninite but occasionally as uranothorite, has been found in 11 localities from the western Adirondack Mountains to North Carolina. About half of them are in iron-rich rocks, most commonly magnetite gneiss, while in Pennsylvania one is a titanium-iron-uranium association. The remainder are not related to any particularly iron-rich mineral assemblage, but even these will often have the uranium closely associated with biotite, chlorite, hornblende, or some other accessory iron mineral. As mentioned earlier, the spatial association of iron and uranium is intriguing and seems to be too persistent to be coincidence. Uranium, moreover, shows a slight preference for the footwall zone of magnetite ore, which further substantiates a genetic relationship.

At Camp Smith in the Peekskill area of the Hudson Highlands uraninite is associated with magnetite and hornblende in a basic pegmatite over a sizable linear area which passes through the footwall zone of the old Phillips pyrite mine. Ore at the Phillips mine consists primarily of pyrrhotite, pyrite, magnetite, and a little chalcopyrite in a gangue of hornblende, pyroxene, and feldspar.[4,8] Amphibolite and masses of extremely coarse-grained hornblendite typify the basic pegmatites and are common within several hundred feet of the Phillips orebody. The highest concentration of uranium at this locality known to the writer is in three of these small pegmatites where magnetite is also present.

Several other interesting occurrences in pre-Cambrian granitic gneiss of New Jersey and New York are associated with magnetite-rich rocks. In one, the mineral uranothorite occurs in an extensive footwall zone of a magnetite orebody. The uraniferous zone is stained red with hematite. Associated radioactive fractures are bordered by red alteration. Interestingly, hematite alteration is a prominent feature of many large uranium vein deposits, particularly those in the pre-Cambrian shield area of western Canada.

In still another deposit bordering magnetite ore, uranium appears to be confined to chlorite-hornblende-magnetite rich layers in tightly folded and drag-folded schistose gneiss. Concentrations of uraninite are localized along the axial parts of these folds. Thus, the uranium seems to form pencil-shaped shoots that lie parallel to the regional plunge. The known shoots are several feet across and of a good grade.

At a third locality uraninite occurs along the contact of a foot-wall gneiss and magnetite ore. The gneiss is rich in ferromagnesian minerals, garnet, and potash feldspar. Unfortunately, the uranium is known only in pockets a foot or two in diameter scattered at random along zones parallel to the gneissic foliation. In places the gneiss is crumpled and although radioactive pods are present, the uranium has no obvious relation to the folds. Faults and shears are present but neither seem to control the distribution of the radioactive minerals. Here, magnetite and ferromagnesian gneiss are a better guide to uranium than structure.

In the Hudson Highlands, across the Hudson River and north of Peekskill, uranium is rather uniformly disseminated through several biotite-rich zones in granite gneiss. Individual zones, only 3 in. across, can be traced for hundreds of feet with no discernible change in strike. Selected samples assay chemically slightly over 0.1 pct U_3O_8.

Promising amounts of uranium have also been found recently in micaceous schist and gneiss in western North Carolina. These are sometimes con-

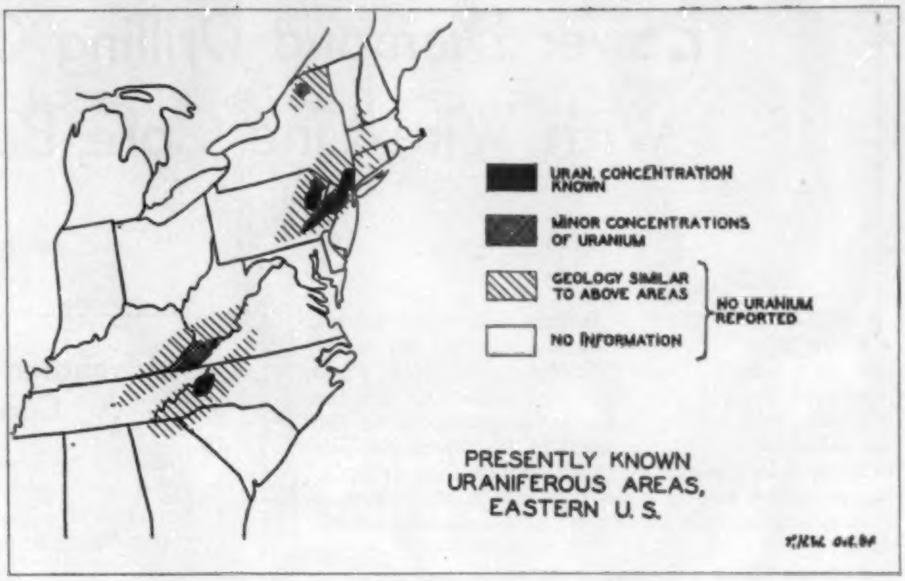
Geochemical Test Procedures

Water Sampling

Radon is radioactive and yields a series of radioactive daughter products with both long and short half-lives which form insoluble sulphides. A sample of well water (½ to 1 liter) is collected, constant weight of $PbNO_3$ added, and H_2S or Na_2S introduced. The lead acts as a carrier and facilitates the precipitation of the insoluble radon daughter products, particularly RaC^1, as sulphides. The precipitate is quickly filtered onto a standard-sized filter and the radioactivity is measured on an α counter, as soon after 30 min has elapsed as possible, but certainly within 1 hr 30 min. As the half life of radon is only four days, the time elapsed between collecting the samples and analyzing should be no more than two days. Although RaC^1 has a half life of 1.5×10^{-4} sec, its decay is controlled by the decay of RaB and RaC, which together have an effective half life of 31 min. Because of this, counting should be done between 30 and 90 min after precipitation. Harley[9] describes how the original radon content at time of collection can be calculated from the radioactivity of the precipitated sulphides.

Soil Sampling

Theoretically, nongaseous metallic daughter products of radon with a long life, such as RaD and RaF, may accumulate overlying uranium. If so, they can be leached from a soil sample with dilute nitric acid which is then filtered, neutralized, and treated like a sample of well water in the first method. Because a long half-life daughter product is being measured, the time between sampling and analyzing is not critical. This technique has not been tried.



The prospector is going to have a major role in the discovery of eastern uranium deposits. Widespread uranium mineralization has been noted despite lack of bedrock exposure. Two geochemical techniques may solve the problem created by overburden and soil.

fined to particular zones, in other cases seemingly related to shears. Where both schist and gneiss occur together, the schist is more apt to contain uranium in interesting amounts.

Exploration Techniques

Uranium prospects have been found in the East. Are there others, and if so, how can they be located?

Known occurrences of uranium mineralization are favorable areas in which to start the search for others. Similar geologic conditions in adjacent areas provide logical extensions of favorable ground. Localities with only minor amounts of known uraniferous material are certainly of interest, for these small concentrations may be evidence of larger concentrations.

Probable exceptions to this rule are the slightly uraniferous marine phosphates of Florida, black marine shales such as the Chattanooga shale, and the monazite placers of the coastal regions. In all of these the uranium seems to have been incorporated during sedimentation and there is neither theoretical nor field evidence to suggest that high concentrations should be expected.

The remaining regions where uranium is not known are not necessarily unfavorable, but rather may have been only inadequately examined.

One of the serious handicaps to uranium prospecting in the eastern part of the country is the lack of outcrops over large areas. Significantly, *75 pct of the known occurrences of uranium in the East have been found in artificial excavations: railroad and highway cuts, quarries, and mines!*

The writer concludes from this that if bedrock were better exposed in New Jersey and Pennsylvania, these two states could boast of many more uranium localities. The problem, then, is how to find ore where it is buried beneath several to many feet of glacial debris, outwash, and residual soil. Even in residual soils the uranium cannot be expected to remain at the surface because it is easily leached.

To help solve this problem requires a quick, inexpensive geochemical prospecting technique, one that will not require expensive and time-consuming quantitative chemical analyses. Two methods were suggested by John Harley of the Health & Safety Laboratory, New York, AEC Operations Office. One method depends upon the high solubility of radon gas in water over a wide range of pH values. The second utilizes the diffusion of the gas through residual soil and other types of overburden.

When percolating ground water encounters uranium it theoretically should dissolve some associated radon gas forming a trail of radon-charged water down stream. This trail provides an enlarged prospecting target. In practice, a sample of well water is tested for radon products. This geochemical method is being field tested in the Triassic Lowlands in New Jersey where outcrops are virtually absent and numerous wells provide adequate sample spacing.

The second approach assumes that radon gas diffuses through the overburden from an underlying concentration of uranium and distintegrates into nongaseous metallic daughter products. Those with a long life, such as RaD and RaF, should accumulate in the soil. The accumulated material can be leached from a soil sample and treated like the sample of water used in the first method.

In the West the AEC and USGS are developing several geophysical and geochemical methods for finding hidden deposits of uranium. When these are refined and established, they may be applicable to the East. The low-level airborne scintillation survey is already in general use.

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* Prepared by USGS for AEC Office of Technical Information Services. Available through Depository Libraries.

Questions and problems on uranium in the eastern United States may be referred to The AEC, Div. of Raw Materials, 1901 Constitution Ave., NW, Washington 25, D. C.

Lower Diamond Drilling Costs With Wire-Line Core Barrel

by V. N. Burnhart

AFTER eight years of testing and development, the E. J. Longyear Co. has adapted the wire-line core barrel to small diameter drillholes. Field performance indicates that the apparatus for the BX hole will be an important supplement to the conventional techniques used in the diamond core drilling industry. Higher core recovery, faster drilling progress, and reduced diamond costs will provide substantial savings to the user of coring equipment.

The wire-line principle is not new, having been successfully applied to the large-diameter holes of the petroleum industry. But scaling the practices of core recovery in oil well drilling down to the small BX hole presented a number of problems. The technique, difficult even for large holes, was complicated by the exacting limitations of the small diameter in which durable and foolproof mechanisms would be required to operate. Since the maximum benefits could be realized from this system in holes 1000 ft and deeper or in holes in badly fractured ground, the drill string would have to be able to withstand heavy stresses. Most vital to the success of the idea was the development of a positive latching mechanism to assure proper positioning of the inner tube of the core barrel when the tube is dropped into place. Lastly, little was to be gained from the wire-line method without diamond bits that would give optimum penetration rates and a long service life in the drillhole.

At the end of 1953 these difficulties had been solved, or eliminated, together with others such as dry hole drilling, angle holes, and incorporation of proved principles for maximum core recovery. The BX size wire-line core barrel and accessory equipment was made available to all users in January 1954.

Operation of the Wire-Line Core Barrel

Upon the completion of a core run or on indications of a core block, the drill string is lifted until the uppermost joint is located conveniently above the swivel head on the drill. The hole is flushed or circulation is maintained as required. After removal of the top rod section, the overshot assembly is lowered down the drillhole to engage the spear of the inner tube assembly. The inner tube is hoisted to the surface and detached from the overshot. A spare tube, already serviced and inspected, is immediately dropped or lowered into the drill string. Coring can be resumed immediately while the load inner tube is cleared of core and serviced.

The serviced inner tube is dropped free in the drill rods if the fluid level in the hole is less than 100 ft below the collar. In dry holes, or where the fluid level is below the 100-ft level, the inner tube

(Continued on page 550)

V. N. BURNHART is Assistant General Manager of E. J. Longyear Co., Minneapolis.

Advantages of Wire-Line Core Barrel

1 Diamond bit and drill string can remain in the hole until the diamond bit needs to be replaced. This reduces the time normally utilized in handling conventional tools and may result in a proportionate increase of net drilling time.

2 With the drill string remaining in the hole for a relatively long period, attrition of weaker strata exposed in the drillhole is minimized. This material is usually responsible for the trouble and expense resulting from caving. Since the bit remains near the bottom of the hole between core runs, drilling over cave is eliminated, thereby increasing shell and bit life. Premature blocking, often caused by drilling over cave, is eliminated with resulting improved core recovery.

3 Core barrel is sturdily constructed and able to withstand severe usage and long service.

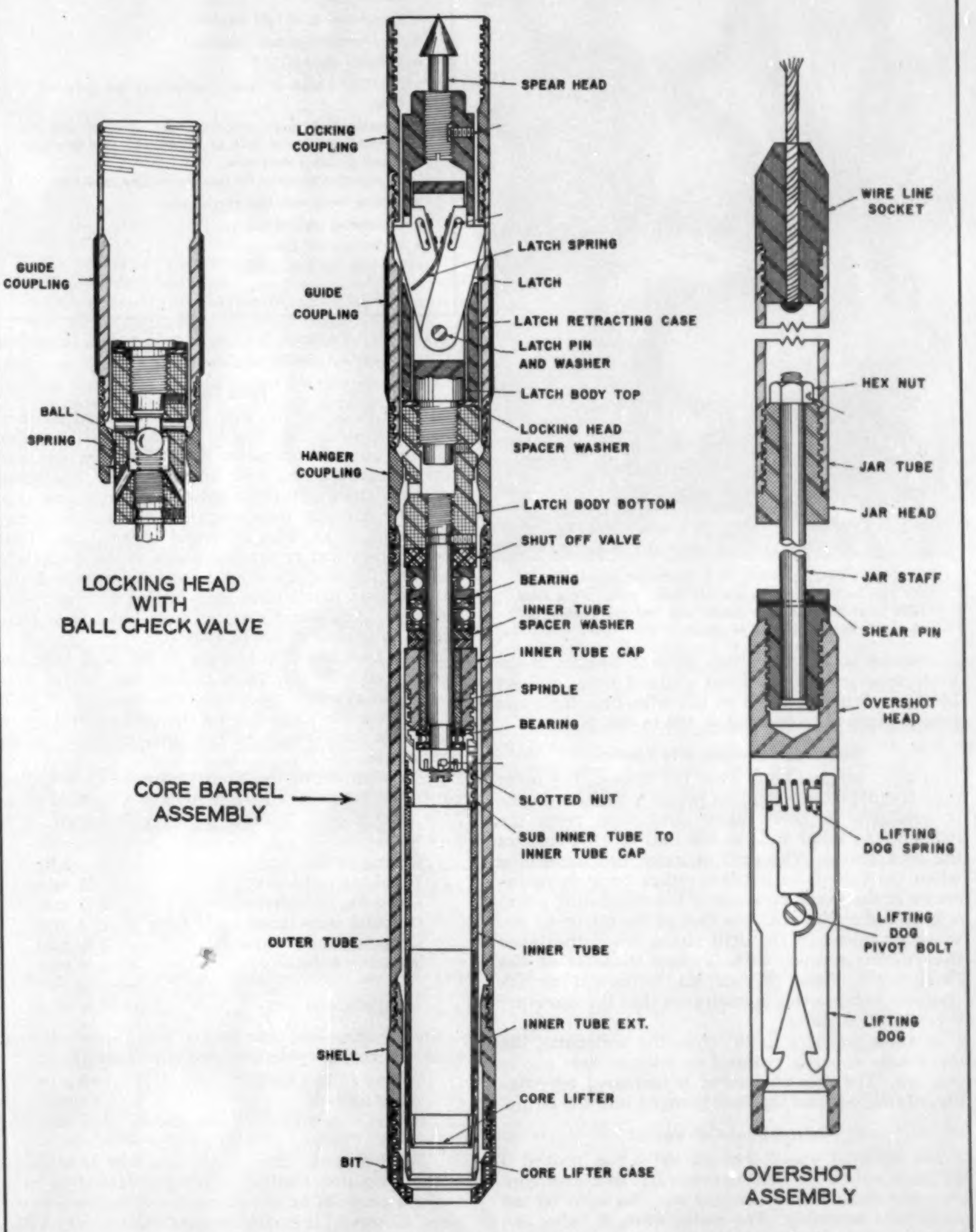
4 Operation of the wire-line core barrel, although somewhat precise for the average diamond driller, requires little in the way of manual effort as compared to the handling of conventional tools. Assume, for example, that the average bit life on a drilling project is 100 ft. Under such circumstances, the drill operator using the wire line and core barrel would normally make a drill-string round trip only once for each 100 ft of hole cored instead of one for each 10 to 20 ft cored with conventional equipment.

5 Core can be extracted with the minimum of physical effort and time. Short core runs in difficult coring ground can be made without pushing the cost beyond economic limits.

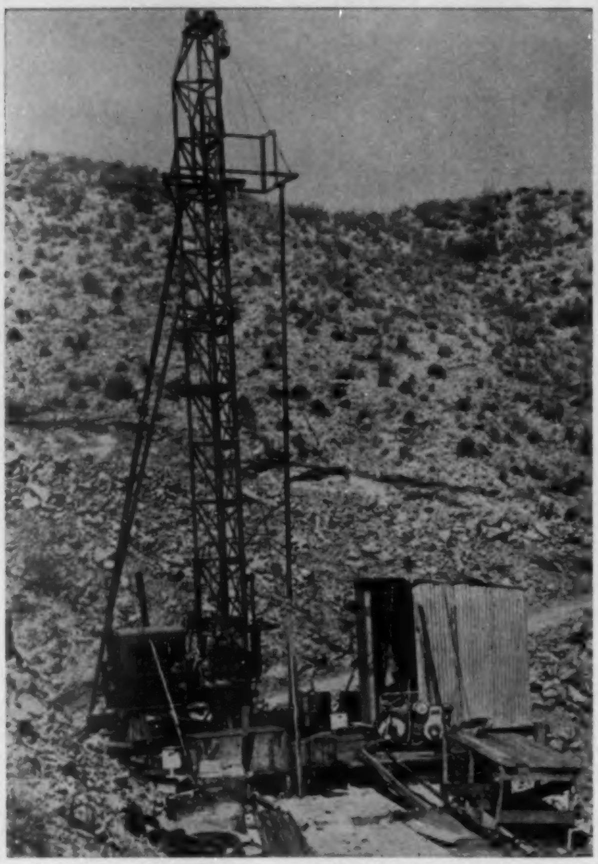
6 The wire-line core barrel can be successfully applied with either screw or hydraulic feed principle.

7 Drillhole angle tests can be made through the inside of the drill string by lowering and retrieving the clinometer on the wire-line.

LONGYEAR WIRE LINE CORE BARREL



Details of construction of the core barrel and overshot assembly. Simple, positive locking mechanisms are necessary for small diameter holes to insure proper drilling position.



Wire-line drilling operation in a Southwest copper district gave user better core recovery and lower costs. More than 75,000 ft of BX hole were drilled with the new method before it was made available to users.

is lowered on the wire-line. Rate of descent of the inner tube in a water-filled vertical hole is about 200 fpm. When lowered on the wire-line, the inner tube is allowed to descend at 400 to 600 fpm.

Inner Tube Pumped Into Position

In tight vertical holes over 700 ft deep, the inner tube is pumped into drilling position. Sufficient time is available to re-establish circulation from the moment the inner tube is released until it reaches the core barrel. The drill operator can determine when the tube is in position either by a sharp increase in the pump pressure, if the circulating pump is in closed circuit with the face of the bit, or by the shock produced in the drill string when the inner tube makes contact with landing shoulder of the outer tube. These signals are important to the operator because this is assurance that the assembly is ready for drilling.

In angle holes up to 30° from the horizontal, the inner tube is easily pumped or lowered into coring position. The rate of descent is increased by rotation of the rods and the fluid pumped into the string.

Water Shut-Off Valve

The optional water shut-off valve has proved a valuable aid to the drill operator. It increases core recovery and reduces diamond loss and wear on the inner tube assembly. The water shut-off valve can be successfully applied only if a closed circuit is maintained between the pump and the face of the bit. Using a closed circuit, the moment a core block develops a sharp increase of pump pressure will be an indication of a core block and the loss of water

BX Wire-Line Core Barrel Equipment

- Diamond bit, approximately 2⅜x1⅛ in.
- Reaming shell.
- Core barrel outer tube assembly.
- Core barrel inner tube assembly.
- Overshot assembly.
- 2 3/16x1 11/16-in. flush coupled wire-line rods—10 ft long.
- Portable high speed wire-line hoist equipped with the required quantity of 3/16 or 1/4-in. wire rope or single-strand stainless steel wire.

Optional accessories for complex drilling conditions.

- Locking head with ball check valve.
- Circulating stuffing box.
- Water shut-off valve.
- Dry hole overshot release.

to the bit. Further drilling would result in serious damage to the diamond bit.

Field Data

In the U. S. the BX wire-line equipment has now been successfully applied to formations with widely varying physical characteristics. These include conditions encountered with coring in the Southwest copper districts, Midwest sediments containing gypsum and fluorspar deposits, and Lake Superior pre-Cambrian rocks with iron and nickel ores. Both sedimentary and crystalline rocks of the Appalachians and the western altered volcanic rocks containing precious metals have been drilled with wire-line methods. Angle and vertical holes have been completed to depths of 300 to 4000 ft.

As of December 1954, some 75,000 ft of hole had been cored with the BX wire-line core barrel, producing an average measured core recovery of 94.01 pct. At various times during the past several years, engineers have recorded the time cycle of coring operations.

A breakdown of the time consumed in a typical coring period with wire-line tools in a vertical drill-hole 1500 ft deep, drilling a cherty limestone, is as follows:

Coring 10 ft	1 hr
Breaking rod joint	½ min
Lowering overshot	3½ min
Hoisting core-laden inner tube	4 min
Dropping inner tube	7½ min
Washing hole	6 min
Total elapsed time	1 hr 21½ min

Under the same conditions using conventional tools, the coring cycle recorded is as follows:

Coring 10 ft (AX)	40 min
Washing hole	15 min
Round trip with 30-ft rod stands	90 min
Total elapsed time	2 hr 25 min

The wire-line method is not considered to be a driller's panacea or a solution to all drilling problems. However, it is now recognized as a very valuable tool which can be used to secure core, under adverse conditions, at a reasonable cost. It is frequently a less expensive method of coring in those areas where the exploration of new ore deposits demands increasingly deeper holes.

INTERNATIONAL MINERAL TRADE SERIES

Part III

World Trade in Chromite

by John D. Ridge and Betty S. Moriwaki

THE significant chromite producers listed in Table III are not major steel producers, with the exception of the USSR. After manganese, chromium is the most important alloying metal in steel. It would not be surprising to find a direct relationship between steel production and chromite imports. The precise connection is concealed by the other uses of chromite and the grades of steel produced by the various countries involved. In addition, the amount of ferrochromium made for export must figure in any calculation.

Norway, a producer of considerable amounts of ferromanganese, imports significant quantities of chromite for ferrochromium manufacture. Most of the ferrochromium is exported to European steel-producing nations. Sweden imports only half as much chromite as Norway but makes far more chromium-bearing steel. Thus Sweden has far less ferrochromium for export, although it supplies about 2000 tons per year to the U.S. and probably somewhat more to such chromite-poor steel producers as Germany and Belgium-Luxemburg. Canada is another chromite importer exporting ferrochromium, sending some 19,000 tons to the U.S. in 1952. The U.S. is Canada's largest source of chrome. It appears that most of the chrome is received from Turkey and then sent on to Canada.

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Chromite, like manganese ore, comes to the U.S. from all over the world, 12 countries supplying more than 10,000 tons each and eight more than 20,000 tons in 1952. Actually the U.S. obtains the bulk of its chromite, more than 85 pct of the 1952 total, from four nations—Turkey, the Philippines, Union of South Africa, and Southern Rhodesia.

In addition to Turkish chromite that first passes through the U.S., Canada gets chromite from the Union of South Africa and Southern Rhodesia and is the biggest importer after the U.S. Belgium-Luxemburg, a minor chromite importer, must obtain chromium from ferrochromium coming probably from Norway, and to a lesser extent, Sweden.

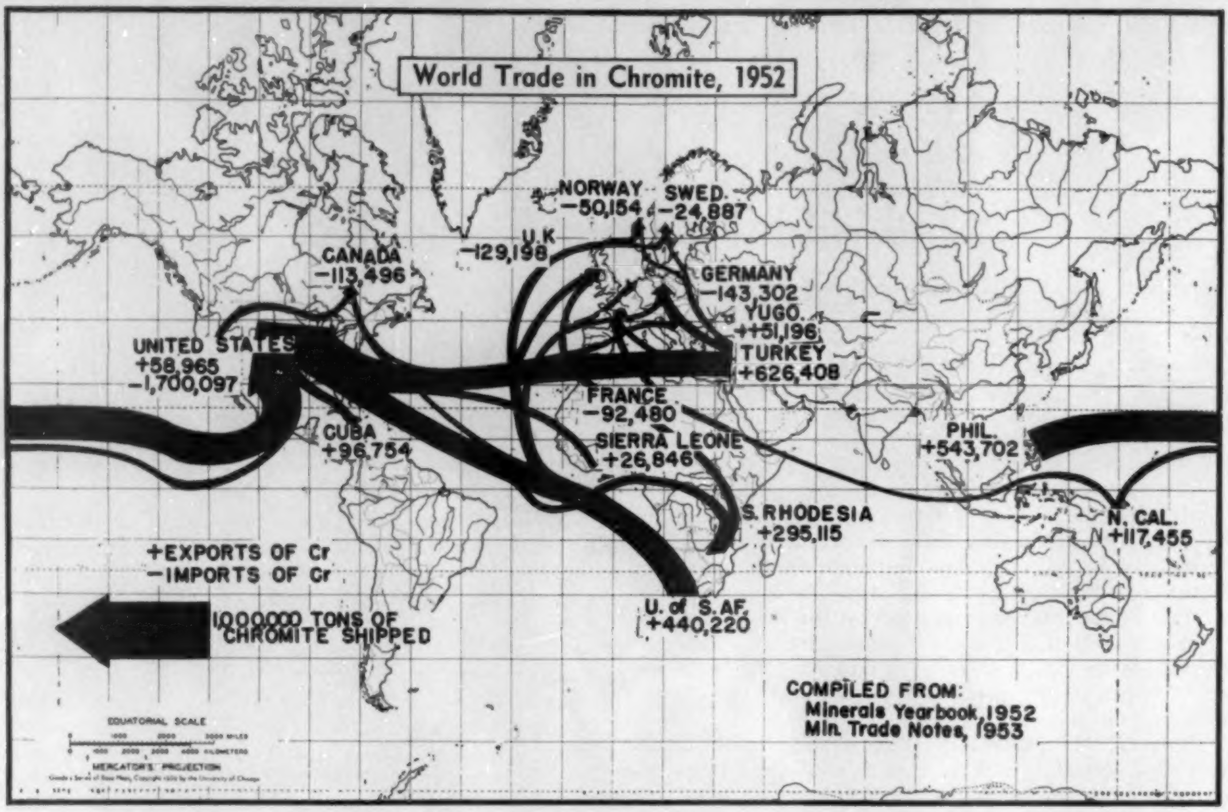
The United Kingdom depended for chromite on African members of the Commonwealth; France on Turkey and New Caledonia; Germany and Austria on Turkey; Norway on Turkey, the Union of South Africa, and New Caledonia; Sweden on Turkey and the Union of South Africa; and Switzerland on Turkey.

It has been demonstrated that despite geographical location, nations rich in solid fuel can and do attract manganese and iron ore. The same is true for chromite. The negligible steel production of the chromite-mining countries assures continued trade in chromite for some time. The several minor

Table III—World Trade in Chromite Ore,* Tons

Exporter	Total**	U. S.	Canada	Germany	Austria	U. K.	France	Norway	Switz.	Sweden	Italy	Misc.	Europe
							Importer						
1952													
Turkey	626,408	424,983	2,032	49,771	39,708	8,790	39,382	14,357	16,115	16,166	—	15,104	(184,289)
Philippines	543,702	543,702	—	—	—	—	—	—	—	—	—	—	—
U. of S. A.	440,924	269,780	40,363	33,623	—	56,606	10,100	12,165	—	8,721	9,566	—	(130,781)
S. Rhodesia	295,510	183,572	12,136	—	—	63,802	—	—	—	—	—	36,000	(63,802)
N. Caledonia	117,455	58,776	—	—	—	—	43,000	15,679	—	—	—	—	(58,679)
Cuba	96,754	96,754	—	—	—	—	—	—	—	—	—	—	—
U. S.	58,965	—	58,965	—	—	—	—	—	—	—	—	—	—
Yugoslavia	50,861	21,661	—	20,200	—	—	—	—	—	—	—	9,000	(20,200)
Sierra Leone	26,846	26,846	—	—	—	—	—	—	—	—	—	—	—
	2,259,430	1,700,097	113,496	103,594	39,708	129,198	92,482	50,514	16,115	24,887	9,566	60,104	(457,751)
1932													
Turkey	55,000	20,100											35,100
Russia	41,500	4,900											36,600
S. Rhodesia	35,400	14,700											20,300
Yugoslavia	30,200	30,200											—
India	23,200	8,000											15,200
U. of S. A.	20,600	1,000											19,600
N. Caledonia	14,200	11,700											2,500
	220,300	90,600											129,300

* Includes all grades. U. S. Production 1952 – 21,304. ** Importer totals may also include tonnages received from minor exporters not large enough to appear individually. Totals of vertical columns, therefore, may be larger than the sum of their listed parts.



steel-making countries behind the Iron Curtain get chromite primarily from Russia, but the amount involved is unknown.

U.S. dependence on foreign suppliers for almost 99 pct of its chromite is a serious problem now and would be an insurmountable situation in an emergency. During World War II, U.S. chromite production reached a peak of 160,000 tons in 1943—almost 10 pct of current consumption. Even if time were allowed for mines to go into production it is doubtful that the U.S. could equal the 1943 output. The problem of locating Western Hemisphere chromite sources is even more difficult than it is for manganese. The seriousness of the situation is somewhat reduced by the possibility of substituting other elements, particularly molybdenum, but not enough to curb the need for intensive study.

Due to a combination of untoward circumstances which the Editors deeply regret, portions of the editorial revision of the Introduction to Pattern of International Trade in Metal Raw Materials, *by John D. Ridge, were not, in the author's opinion fairly presented. The Introduction appeared in the May issue of* MINING ENGINEERING. *The corrected material will be published in July, and will be included in reprints of the series in the proper place.*

The International Mineral Trade Series—

In this issue MINING ENGINEERING presents the third and fourth parts of a continuing series of articles on movement between nations of the vital minerals, the essential metal raw materials. Part I and Part II appeared in the May issue.

Additional articles in the series will appear in forthcoming issues. The complete series includes the following subjects:

Introduction: Factors Controlling International Trade in Metal Raw Materials—John D. Ridge

Part I: IRON ORE—J. D. Ridge and B. S. Moriwaki

Part II: MANGANESE ORE—J. D. Ridge and B. S. Moriwaki

Part III: CHROMITE—J. D. Ridge and B. S. Moriwaki

Part IV: NICKEL Concentrates and Metal—J. D. Ridge and B. S. Moriwaki

Part V: COPPER Concentrates and Metal—J. D. Ridge and R. C. Barwick

Part VI: LEAD Concentrates and Metal—J. D. Ridge and R. C. Barwick

Part VII: ZINC Concentrates and Metal—J. D. Ridge and R. C. Barwick

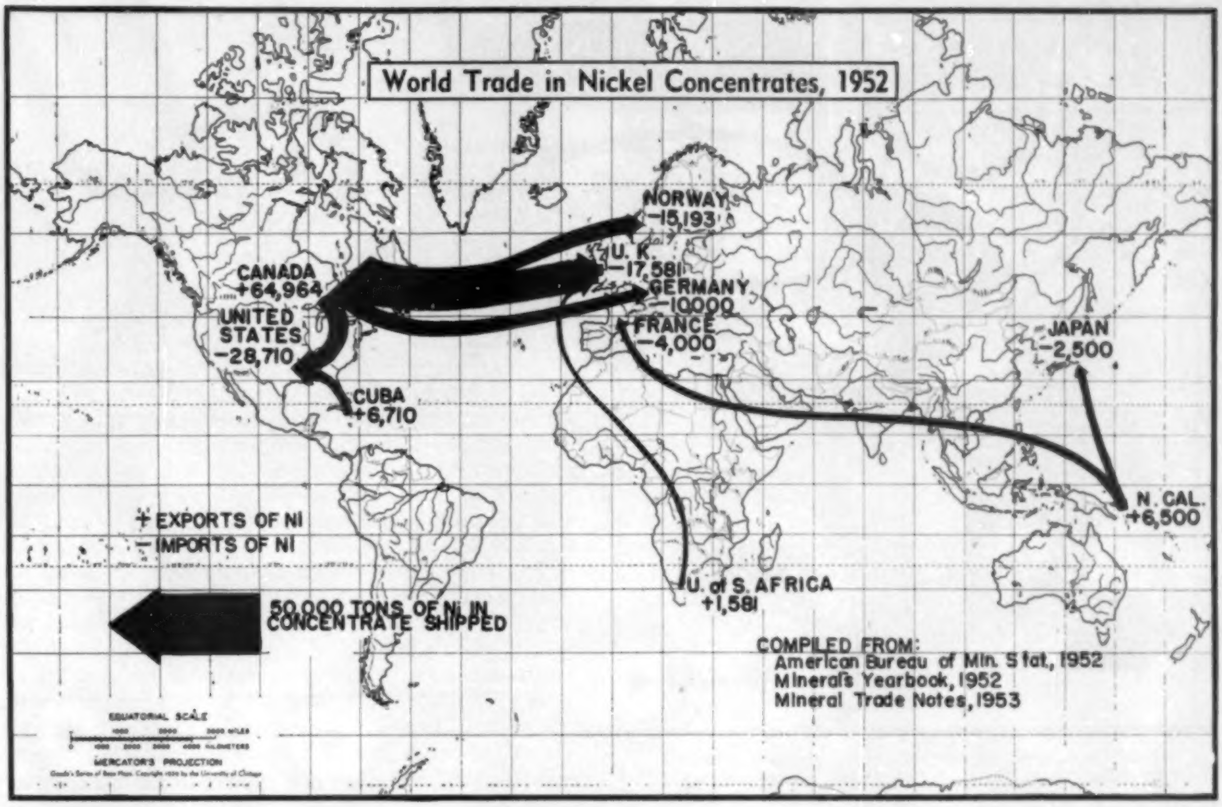
Part VIII: TIN Concentrates and Metal—J. D. Ridge and R. C. Barwick

Part IX: MERCURY—J. D. Ridge and R. C. Barwick

Part X: BAUXITE—J. D. Ridge and R. C. Barwick

Part XI: ALUMINUM—J. D. Ridge and R. C. Barwick

REPRINTS: No requests for reprints will be filled until the completion of the series. At that time an announcement will be made in MINING ENGINEERING as to availability of the complete series of articles.



INTERNATIONAL MINERAL TRADE SERIES

Part IV

World Trade in Nickel Metal and Concentrates

by John D. Ridge and Betty S. Moriwaki

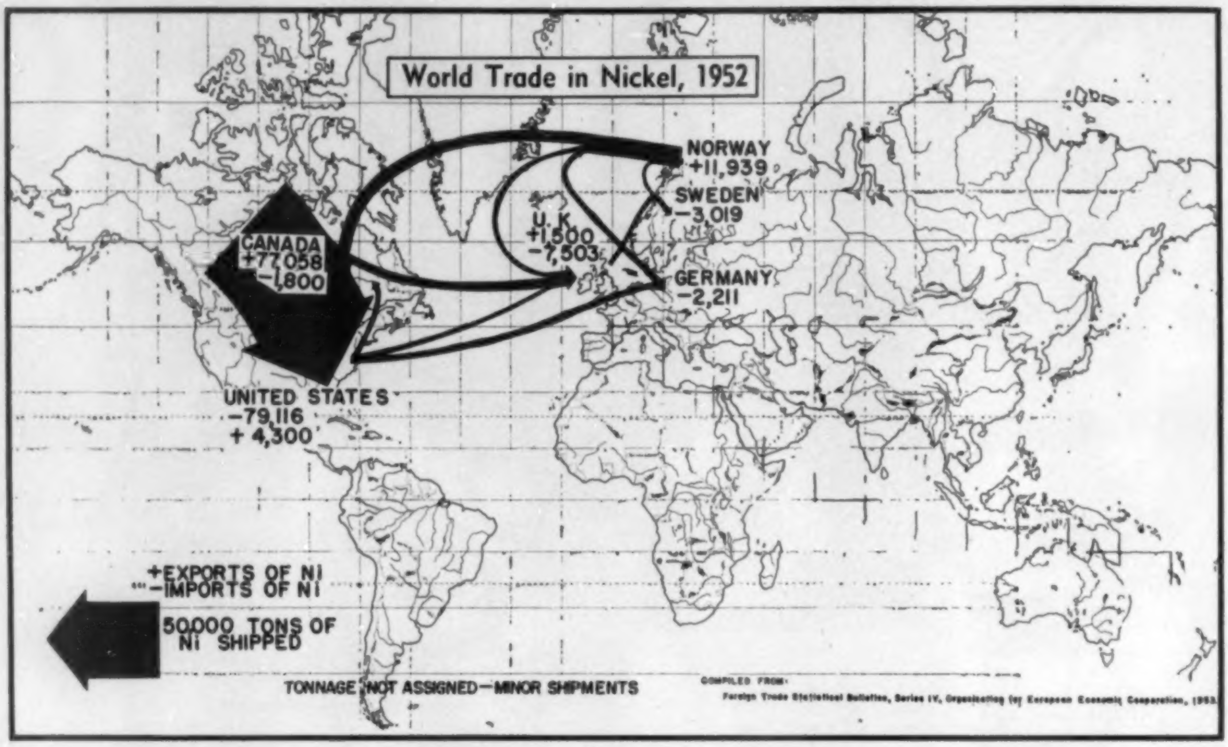
THE problem of drawing the line between nickel in concentrates and nickel metal is more difficult than for the average metal and its concentrate. An appreciable fraction of the nickel imported by the U.S. in both forms, and essentially all the nickel in the material sent to Norway, is re-exported. (Norway is an important refiner of Canadian nickel.) The actual amount of exported nickel concentrates is slightly less than 90,000 tons; add to this 77,000 tons of refined nickel exported by Canada for a total of slightly more than 165,000 tons of nickel in international trade in 1952.

The USSR is the only large steel producer among the nickel-producing nations, and its nickel does not enter into Free World trade patterns. While Russia's nickel production is only about one fifth of Canada's,

Table IV—Nickel in Concentrates,* World Trade in Tons
1952

Exporter	Total	Importer U. S.	Norway	U. K.	Germany	Japan	France	Misc.	Europe
Canada	64,964	22,000	15,193	16,000	10,000**	—	—	1,771	(41,193)
Cuba	6,710	6,710	—	—	—	—	—	—	—
N. Caledonia	6,500	—	—	—	—	2,500	4,000	—	(4,000)
U. of S. A.	1,581	—	—	1,581	—	—	—	—	(1,581)
	79,755	28,710	15,193	17,581	10,000	2,500	4,000	1,771	(46,774)

U. S. Production 1952 – 633 (primary) tons.
* Includes ore, matte, fonte, oxide, and oxide sinter.
** Probably re-exported from U. K.



it is greater than that of the three other important nickel exporters.

Canada's 1952 steel production was 3.65 million tons. Its nickel in ore production was 127,000 tons. Obviously Canadian steel producers had no need for huge quantities of nickel, and 142,022 tons of nickel went abroad in one form or another, as illustrated by Tables IV and V. Concentrates, including matte, oxide, and oxide sinter, went to the U.S., the United Kingdom, Germany, and Norway. The only other important exporters were Cuba, New Caledonia, and the Union of South Africa, and none of these exported fully refined metal. Cuban exports went entirely to the U.S., and those of South Africa to the United Kingdom. New Caledonia shipped to France and Japan. No other country received nickel concentrate in amounts worth noting.

Canada exported more refined nickel in 1952 than concentrates. Some 95 pct of the refined metal went to the U.S. and the rest essentially to the United Kingdom. France refined a considerable amount of nickel in 1952 but does not appear to have exported an important amount, although it is possible that some nickel went to Belgium-Luxemburg. Norway sent half her production to the U.S. and the remainder was almost equally divided among the United Kingdom, Germany, and Sweden. Although the U.S. produced only a few hundred tons of primary nickel in 1952 as a byproduct of copper ore refining, it exported about 4300 tons of refined nickel and nickel-bearing alloys. About 1800 tons went to Canada, a similar amount to the United Kingdom, and the remainder to Japan and Germany. Incidentally, the copper ores were not of Canadian origin. The amount of nickel trade between the USSR and her satellites is unknown.

The U.S. is even more poorly endowed with nickel ore resources than it is for manganese and chromium. However, the nickel situation is much less a problem because of the nearness of Canadian and Cuban sources. Enemy action short of complete conquest would not cut off supplies.

Table V—Refined Nickel Metal, World Trade in Tons

1952

Exporter	Total	Importer: U. S.	Japan	U. K.	Germany	Canada	Sweden	Misc.	Europe
Canada	77,058	73,291	—	4,000	—	—	—	—	(4,000)
Norway	11,938	5,825	—	1,703	1,911	—	1,519	980	(5,133)
U. S.*	4,300	—	400	1,800	300	1,800	—	—	(2,100)
U. K.	1,500	—	—	—	—	—	1,500	—	(1,500)
	94,796	79,116	400	7,503	2,211	1,800	3,019	980	(12,733)
1932									
Canada	14,600	7,500	200			—			6,900
N. Caledonia	2,900	—	—			—			2,900
Europe	2,600	900	2,400			—			—
India	700	—	—			—			700
U. S.	700	—	—			100			600
	21,500	8,400	1,700			100			11,100

* Includes nickel content of alloys. U. S. Production 1952 — 633 tons of primary ore in terms of metal content.

Two Cost-Cutting Applications of Instrumentation

Case I: Using Remote Control for Long Pipelines

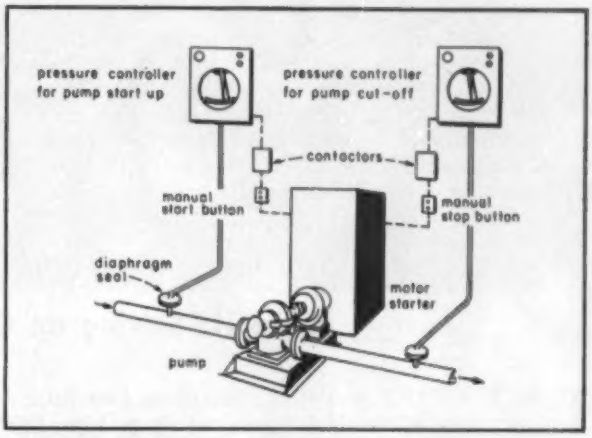
LONG pipelines handling suspended solids find wide use throughout the mining industry. In phosphate, iron ore, and clay mining; in hydraulic stripping of overburden; in tailing disposal; and in transferring concentrates between plants pipeline transport may prove cheapest material handling method. One drawback is necessity for providing attendance at booster stations, both for control and for protection of pumping equipment from sudden surges and failures. Thiele Kaolin Co. in Georgia has come up with an installation where instrumentation does this job automatically, efficiently, and economically.

A booster pump helps to handle the flow of clay slurry through 9 miles of 6-in. pipe in this time-saving application of industrial instruments. Operated by a variety of automatic control devices the booster pump is housed in a small, all-metal building isolated in a deep valley near Sandersville, Ga. The building is midway between the firm's mine and its processing plants. Control devices automatically start and stop the pump action to coincide with the main pump on-off cycles where otherwise a workman would have to travel the 4½ miles to the booster pump station to handle its operation.

Kaolin clay—used as a filler in rubber and paint and as filler and coating material in paper products—is mined by a 1½-yd dragline and fed into a portable blunger located at a claypit. Here it is pulverized and slurried before going through a classifier and a final separator, where sand and other foreign matter are removed. Finally the clay moves to a large agitator-equipped tank before being pumped 9 miles to the main processing plant.

The main pump, located next to the agitator tank, is a centrifugal type, driven by a 100-hp motor at 3600 rpm against a 500-ft head.

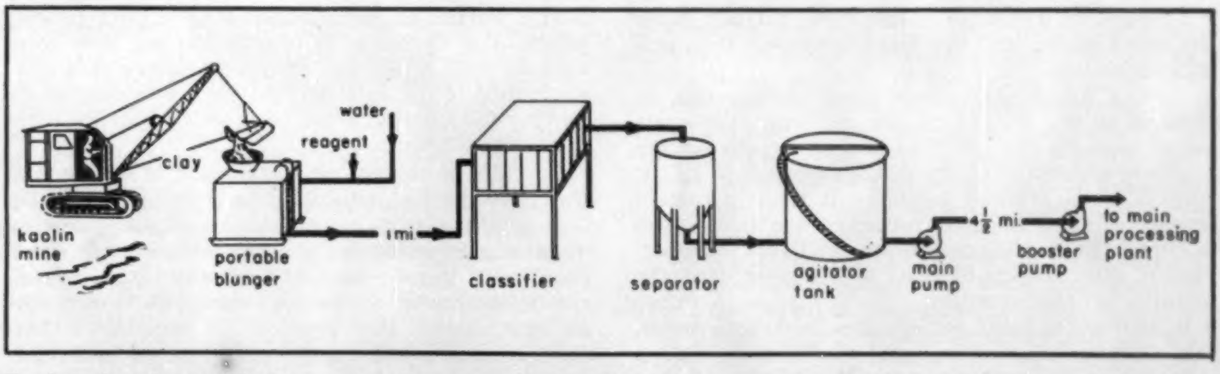
Since the booster is also a centrifugal pump it was necessary to shut it off when the main pump stopped or run the risk of damage as the pump suction head dropped to zero. The problem was aggravated by the fact that the main pump is operated intermittently, starting and stopping several times a day. To eliminate the necessity of sending a man 4½ miles each time the main pump was shut down, Kaolin decided to design the pump operation so this on-off function could be automatically handled.



Schematic diagram shows control installation on booster pump for long pipeline. Control center is 4½ miles away.

The automatic pump control system shown in the schematic illustration saves the firm an average of $10 per day. Included in this system are two indicating pressure controllers designed by Minneapolis-Honeywell's Industrial Div. which incorporate timers, signal lights, and Electr-O-Vane electronic control units. One instrument measures the pipeline pressure on the discharge side of the pump and acts to cut off the pump when this pressure drops below a preset value, at present 150 psig. The second instrument measures pressure on the suction side of the pump and starts up the booster pump when this pressure rises to a preset value, at present 100 psig. To prevent the slurry from getting into the measuring spirals of the instruments, diaphragm oil seals are used.

Control units in both instruments actuate contactors which, in turn, operate the motor starter.



Flowsheet shows layout of kaolin operation. Remote control added to booster pump saved repeated trips to shut down and start it up.

Signal lights in the instruments indicate motor operation when the pump is under automatic control and there are also manual start-stop push buttons in the control circuit. Timers are included in both instrument control circuits so that momentary variations or pulsations in pipeline pressure will not cause cycling of the motor.

Once the control indices and timers have been set at the desired values operation of the booster pump is entirely automatic. If the main pump shuts down, suction pressure and consequently discharge pressure of the booster pump begins to drop. When this discharge pressure moves below 150 psig the pump cut-off controller energizes its timer. If, at the end of the set time, the discharge pressure is still below 150 psig, the controller shuts off the booster pump. On the other hand, if the pressure drop was of a temporary nature, and line pressure returns to some value above 150 psig before the timed cycle is completed, the timer is automatically reset.

When the main pump is started up, suction pressure at the booster pump begins to build up. As soon as this pressure reaches 100 psig, the pump start-up controller energizes its timer. If, at the end of the timed period, suction pressure is still 100 psig or more, the controller starts up the booster pump. As in the case of the cut-off controller, the timer guards against false controller action that could be caused by temporary pressure surges. If the suction pressure falls below 100 psig before the timed cycle is completed, the timer is automatically reset for another cycle.

Controllers, contactors, and relays are all located in the metal structure that houses the booster pump, along with a small pump and accumulator tank utilized for supplying gland water under pressure. Water for this purpose is drawn from a nearby creek. With the exception of periodic inspection purposes, it is not necessary for anyone to visit this isolated building.

Case II: Solving an Ore Feed Rate Problem

T. H. STEWART and R. A. MacDonald of International Minerals & Chemical Corp. have installed an ore feed rate controller at Carlsbad, N. M. It is simple and rugged, without electrical hazards, and provides flexible control. A pilot plant had been set up to process ore continuously, and reagent addition could not be accomplished properly if the ore feed rate varied. The problem, then, was to control the flow of ore from the bin onto a conveyor belt that feeds the plant.

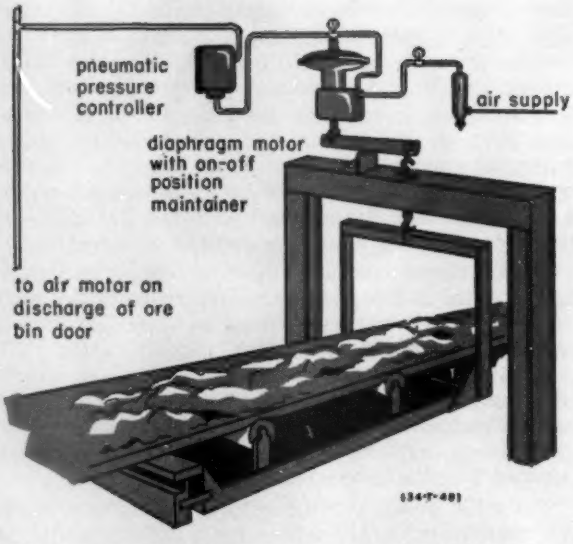
A conventional scale cradle supports one end of a short section of the conveyor belt and its rollers. Bolts or ball bearings at the other end of this section serve as a fulcrum knife edge. The cradle end has a rather complicated linkage to the valve diaphragm motor. The top of the cradle is connected to one end of a beam which pivots on a fulcrum knife edge. The other end of the beam is precisely fitted to the end of the stem of the diaphragm motor. The less play in these connections, the closer the control.

Air supply is piped through a pressure regulator to a gage, through the valve positioner, to the diaphragm motor via a cross fitting with an air gage installed on top, then to a capacity tank, and finally into the bellows of the pneumatic pressure controller. The pressure controller is hooked into another air line that supplies air to an air motor on the door of the ore bin.

Changes in weight of material on the belt move the valve motor, and the valve positioner then acts as a controller.

As the diaphragm motor stem moves, due to changes in the weight on the conveyor, the positioner changes the air pressure to the diaphragm motor to endeavor to stop it from moving, or to return it to its original position. It takes a certain amount of air pressure to reposition the stem which is connected to the scale beam, and this air pressure is directly proportional to the weight of the material on the conveyor.

In addition to being fed into the diaphragm motor, this air now becomes a signal in effect and is fed into the sensing bellows of the Honeywell pressure



Steady ore supply for pilot plant is provided by this economical and ingenious installation.

controller. The pressure controller, in turn, transmits its control air to an air motor on the door of the ore bin so that the door opens and closes as weight on the conveyor varies.

This particular installation is on a pilot process where it is desirable to change the ore flow from time to time to deliver more or less ore at a constant rate. Flow rate may be varied as desired by moving the fulcrum knife edge or the balance point of the scale beam.

The idea is clever, the installation is simple, and the controller keeps the loading from being uneven.

In addition to being a good example of instrumentation at work, this is a unique use of the valve positioner. Usually a valve positioner is used to correct minor variations in the stem position of a diaphragm motor. Here, instead, it becomes a controller and provides an air signal for ore feed regulation.

Use of Autoclaves and Flash Heat Exchangers At Beaverlodge

by R. W. Mancantelli and J. R. Woodward

IN 1947 a large low grade deposit of uranium was located in the northwest corner of Saskatchewan, in the Beaverlodge property of Eldorado Mining & Refining Ltd. Most of the values occur as thin seams and as coatings on other minerals, and the ore, which is light and friable, is not amenable to the usual gravity methods of concentration. The acid leaching process developed to retreat the company's Port Radium tailings was also impractical, as the percentage of carbonates is high and the percentage of sulphides relatively low.

Construction of the mill building and installation of equipment, both scheduled for 1952, awaited selection of a satisfactory ore dressing process on or before Oct. 1, 1951. An extensive research program on dressing of ores from the Ace mine therefore was undertaken by the Mines Branch in Ottawa, a research team at the University of British Columbia, and an ore dressing group at the company's Port Hope refinery.

Pilot plant operations were conducted at the Ottawa plant of Sherritt Gordon Mines Ltd. under the general direction of C. S. Parsons, consultant on metallurgy and ore dressing for Eldorado. In mid-September, having compared results of the several research programs, Dr. Parsons recommended a process employing a carbonate or basic leach. He reported that, while the chemistry of the process had been proved, engineering of the flowsheet was incomplete, and he suggested that under normal conditions further pilot plant work at the Ace mine might be profitable. However, since this would involve a delay of 12 to 18 months in bringing the property into operation, he recommended that design of the concentrator proceed immediately.

Concentrator capacity was determined by two considerations: 1) the amount of ore then available and 2) the expectation that continued improvements would be made in the ore dressing process as a result of the intensive research being carried out by the Mines Branch of the Department of Mines and Technical Surveys. As these improvements could affect both the chemistry and the en-

R. W. MANCANTELLI and J. R. WOODWARD are Mill Superintendent and Assistant Mill Superintendent, respectively, Beaverlodge Operation, Eldorado Mining & Refining Ltd., Saskatchewan, Canada.

Discussion of this paper, TP 4038BD, may be sent, 2 copies, to AIME by Aug. 31, 1955. Manuscript, Oct. 25, 1954. Chicago Meeting, February 1955.

The Transactions papers appearing in Mining Engineering during 1955 will subsequently appear in AIME Transactions Vol. 202 and may be permanently referenced to that volume.

FORMULAS

A) $U_3O_8 + \frac{1}{2}O_2 \rightarrow 3UO_3$

B) $U_3O_8 + \frac{1}{2}O_2 + 9Na_2CO_3 + 3H_2O \leftrightarrows 3Na_4UO_2(CO_3)_3 + 6NaOH$

C) $4FeS_2 + 15O_2 + 16Na_2CO_3 + 14H_2O \rightarrow 4Fe(OH)_3 + 8Na_2SO_4 + 16NaHCO_3$

D) $NaHCO_3 + NaOH \rightarrow Na_2CO_3 + H_2O$

E) $Na_4UO_2(CO_3)_3 + 4NaOH \rightarrow Na_2UO_4\text{ppc} + 3Na_2CO_3 + 2H_2O$

$2Na_4UO_2(CO_3)_3 + 6NaOH \rightarrow Na_2U_2O_7\text{ppc} + 6Na_2CO_3 + 3H_2O$

F) $2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$

G) $Na_2CO_3 + CO_2 + H_2O \rightarrow 2NaHCO_3$

Fig. 1—Chemical reactions necessary to extract and precipitate the uranium are listed. Details of the chemistry have been published.[1]

gineering of the flowsheet, it seemed unwise to provide milling capacity beyond the immediate requirements. The decision was made, therefore, to start construction of a concentrator at once.

Mineralogy

The ore is a red-brown granitic rock consisting mostly of feldspar densely impregnated with hematite. The granite, or aplite, has been severely fractured, and the fractures are filled with veins of calcite, chlorite, quartz, and pitchblende. In order of abundance, the opaque minerals are hematite, pyrite, pitchblende, chalcopyrite, galena, and trace amounts of five or six others.

Ore minerals occur in relatively narrow veins and stringers or in local disseminations in the host rocks. When examined under the microscope, specimens of what appear to be massive pitchblende up to 1 in. wide are found to be heavily contaminated with gangue and other minerals. The main concentrations of pitchblende are usually found in veins in calcite or chlorite, with some in the neighboring host rocks.

Chemistry of the Process and Mill Flowsheet

The process consists briefly of grinding the ore to liberate the uranium minerals, dissolving the uranium in sodium carbonate, separating liquids from solids, and precipitating uranium from solution by sodium hydroxide. Fig. 1 lists several of the chemical reactions necessary to extract and precipitate the uranium. Details of the chemistry, which are well known, have been published.[1]

Except that autoclaves are used for the leaching instead of the conventional agitators, see Fig. 2, the flowsheet resembles that of a simple cyanide plant. The ore is crushed underground, hoisted to an ore pass at surface level, and conveyed to the mill crushing plant. The mill crusher consists of a Symons standard and a Symons short head in closed circuit with Denver-Dillon screens fitted with 4x⅜ in. slots. Grinding to 78 pct −200 mesh is done in two Allis-Chalmers ball mills in closed circuit with Akens classifiers.

After primary thickening, leaching takes place in the autoclaves, which are run at 220°F and 80 to 90 psig. To save heat, an exchange system is used between the pulp entering and the pulp leaving the autoclaves.

The cooled pulp from the autoclaves is pumped to two Dorr washing thickeners in parallel, and thickener underflow is filtered on Northern Foundry filters with a water spray displacement wash. Pregnant solution from the top of the washing thickeners is clarified and precipitated with strong caustic in stirred tanks. Precipitate goes to filter presses and is then dried and packed for shipment. The barren solution, which is strong caustic, is carbon-

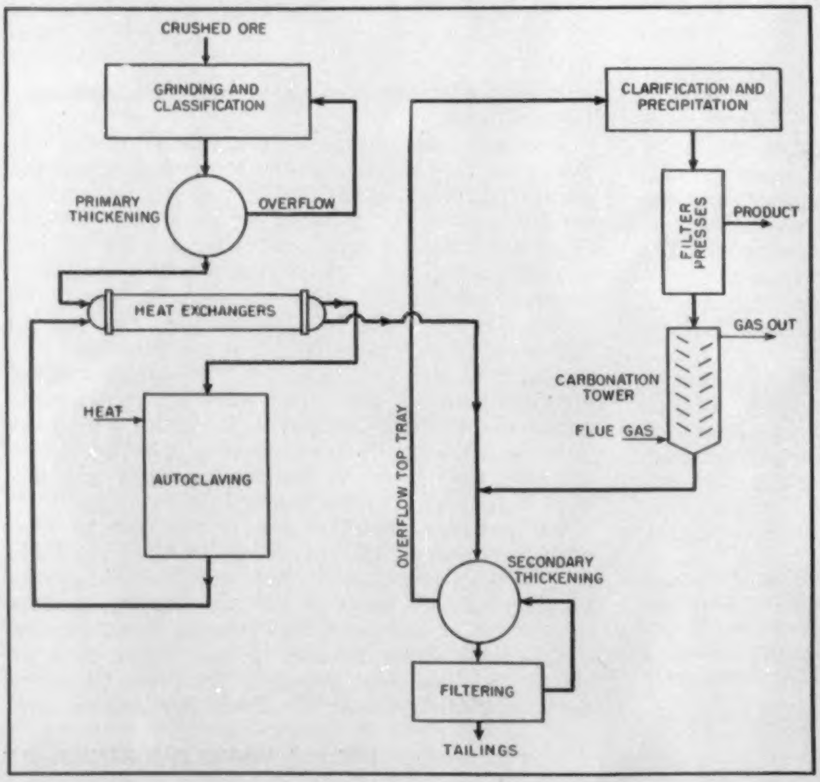


Fig. 2—Flowsheet of the Beaverlodge hydrometallurgical plant is given schematically. Note that autoclaves are used for leaching instead of the conventional agitators and that flash heat exchangers have been substituted for normal tubular ones.

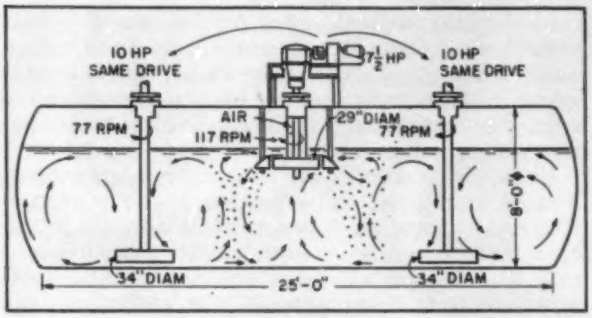


Fig. 3—Diagram shows action of the Beaverlodge autoclaves where dissolution of the uranium takes place.

ated with boiler flue gases in an absorption tower before being recirculated to the process.

Autoclaves

With a few exceptions such as the autoclaves and heat exchangers, the standard equipment found in any gold or base metal plant is used in the mill. The autoclaves, where dissolution of the uranium takes place, are tanks 25 ft long by 8 ft in diam, insulated with 3 in. of fiber glass. Their long axis is in a horizontal position.

Each tank is equipped with three turbomixers. The two end mixers, with 42-in. impellers running at 62 rpm, are used to keep the pulp in suspension. The center mixer, equipped with a hood ring and a 27-in. impeller running at 140 rpm, is used to mix air thoroughly with the pulp. Each mixer is driven by 10 hp, or 30 hp per autoclave.

At present the autoclaves, Fig. 3, are operated at 80 psig and 230°F. Head room of 20 pct is allowed for circulation of the necessary air at 1000 cfm, three to five times the stoichiometric amount of oxygen needed. Two parallel banks of autoclaves are mounted on an 8° slope to provide flow by gravity from one to the next.

Formerly autoclaves were equipped with 1.6 pct manganese steel removable erosion plates fastened to the lower half of the vessel, but these were removed when it was found that erosion was negligible. In a few instances some local pitting corrosion was observed on the steel shell behind the erosion plates. This may have been caused by a local concentration cell, such as might be found under a deposit of sulphides.

It was anticipated that there would be trouble with packing glands of the turbomixers operating under pressure and temperature, but fortunately this has not developed. The impellers used for agitation have not shown the expected wear, although metal has been lost at and near the outer edges.

General Corrosion in Autoclaves: Although some general attack has taken place on the autoclaves, it is not enough to be considered significant. Below the liquid line, attack by leach solution is negligible. Pulp deposits below the liquid line do not give much difficulty except in such restricted areas as those behind erosion plates. Above the liquid line, the vapor is in contact with an air-vapor mixture (74 psi air and 21 psi steam at 220°F). Some CO_2 is also present in the vapor phase originating from the air (300 ppm) and from decomposition of the sodium bicarbonate.

$$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$$

Over a period of years the rust which sometimes attacks the steel exposed to the vapor phase may cause some loss in wall thickness. Drainage lines are observed when autoclaves are inspected.

Pitting Corrosion: The severe pitting on steel at the liquid line, sometimes extending above the line as high as 12 to 14 in., is invariably associated with pulp splash. It is believed that the driving force of the corrosion cell is caused by what is known to corrosion technologists as *differential aeration*. Briefly, it is postulated that the oxide film on steel is not repaired by oxygen from the air because of the limited supply available under a pulp splash. Ferrous ions enter the pulp at such weak spots (anodes) and hydrogen forms at the local cathodes at the edges of the splash. Oxygen removes the hydrogen (depolarization) and the action continues.

Most severe pitting is that associated with a sulphide-rich froth that floats on the surface of the ore stream and clings at certain areas to the walls of the autoclave. The froth has been shown to contain sulphides, graphite, and ferric and cupric ions,

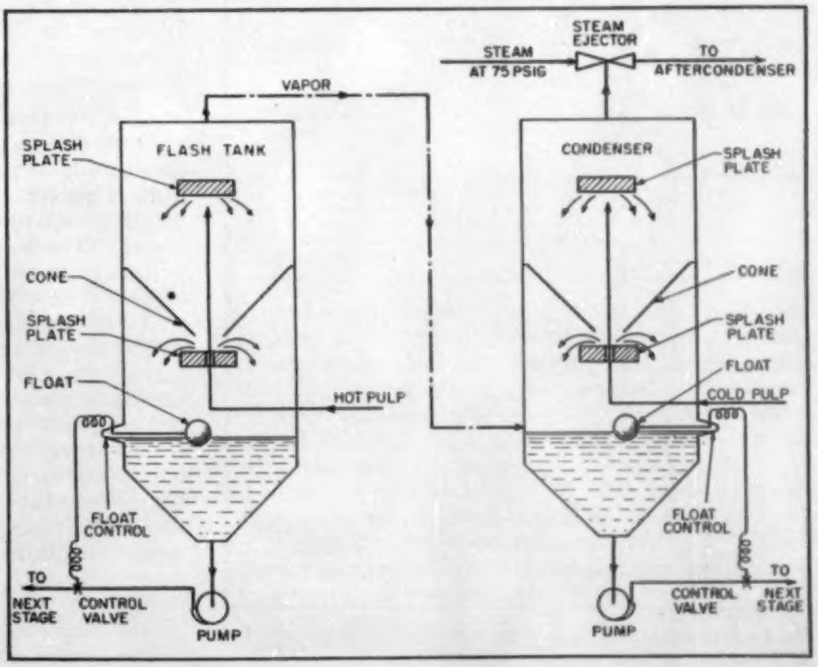


Fig. 4—Flash heat exchangers were used in the Beaverlodge operation instead of normal tubular ones, since it was thought that pulp at 55 pct solids would quickly plug small-diameter tubes and wear out thin tube walls necessary to effective heat transfer.

all of which promote the action of the corrosion cell mentioned previously.

Other factors which may affect the pitting attack are the buildup of sodium sulphate and the presence of chlorides. Only traces of chlorides are found in the Eldorado solutions.

The problem of corrosion, which was turned over to Battelle Memorial Institute for study, resolved itself into three phases: 1) to find some means of keeping the present tanks on stream, 2) to find a material suitable for building future autoclaves, and 3) to determine the basic cause of corrosion. Research on all three phases is proceeding with some success. At the same time a routine program of inspection and repair is being carried out.

Flash Heat Exchangers

When the plant was designed, it was generally agreed that the normal tubular heat exchangers could not be employed to transfer heat from one abrasive viscous pulp to another. Because it was thought that the pulp at 55 pct solids would soon plug the small-diameter tubes and wear out the thin tube walls necessary to effective heat transfer, the flash heat exchangers described subsequently were substituted, see also Figs. 4 and 5. In the light of further experience, tube heat exchangers are now being tried and first results are promising. These units will be the subject of a later article.

The Beaverlodge flash heat exchanger has four identical stages, each consisting of one flash tank and one condenser. The eight tanks in the system are 2 ft in diam and 8½ ft high. The four flash tanks are used to draw heat from the hot pulp leaving the autoclaves, and the other four tanks, interchangeable and of similar design, condense the hot vapor and pass the heat into the cold pulp entering the autoclaves. Auxiliary equipment consists of pumps, control valves, and surge tanks.

The transfer of heat from the flash tanks to the condensers is accomplished by the creation of a vacuum by the condenser. This occurs when the

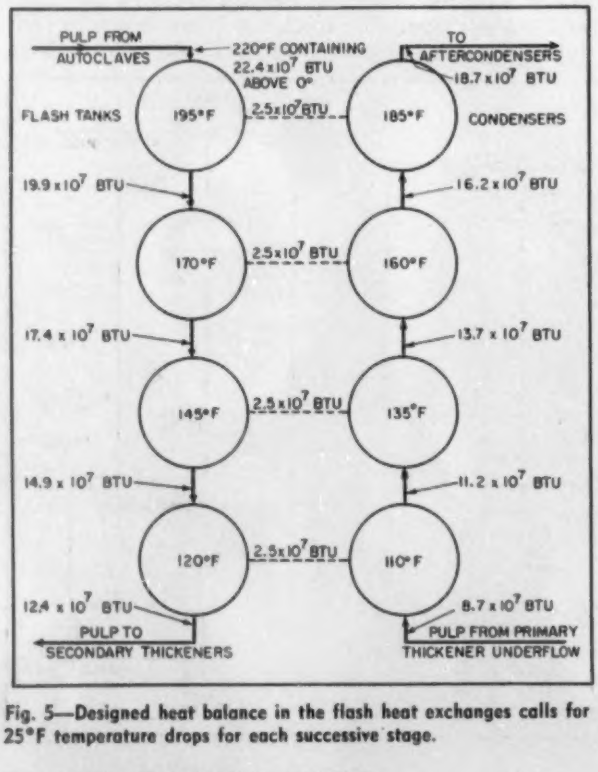


Fig. 5—Designed heat balance in the flash heat exchanges calls for 25°F temperature drops for each successive stage.

heat-carrying vapor liquifies on the relatively cold pulp in these tanks. The vacuum lowers the boiling point of the pulp, and because of the latent heat of vaporization a large amount of heat is transferred from the flash tanks to the condensers in a relatively small amount of vapor.

In its simplest form the exchanger is a combination of flash tank and condenser. The condenser creates the required vacuum, while a steam jet air ejector eliminates the noncondensible gases to maintain the vacuum. Without the ejector, the gases would collect, eventually fill the condenser, and prevent heat exchange.

Because of expected wear, the vessels are heavily protected with liners and splash plates, and all internal parts are readily removable. A whole vessel can be disconnected from the circuit and replaced with an extra tank kept for emergencies, and parts can be replaced quickly.

The pulp is pumped through the center pipe, see Fig. 4, and impinged against the underside of the top splash plate so that an umbrella film is produced. The outer circumference of the umbrella is the wall liner of the vessel. The pulp runs down in a thin film to a baffle or cone where it is brought to the center of the tank to fall on another splash plate, from whence it drops into the well of pulp maintained at the bottom of the vessel. The thin film of pulp is maintained for easy relief of vapor and carried over to the other part of the unit, where it condenses on the surface of the cold pulp cascading down the condenser.

The design called for pulp to leave the autoclaves at 220°F, to drop to 195°F in the first stage of the flash tanks. At 500 tons per day and 55 pct solids, this means that 2.5×10^7 Btu per day have been flashed off in the first stage, see Fig. 5. The pulp will drop an additional 25°F in each successive stage, i.e., from 195° to 170° to 145° to 120°F, which is the temperature of the pulp entering the secondary thickeners.

On the condenser tank side of the heat exchanger, the pulp from the primary thickener underflow, at a temperature of about 85°F, will be stepped up to 110°F by the 2.5×10^7 Btu flowing over from the flash tanks in the first stage. It will be stepped up by 25° increments to 185°F by the time it leaves the last stage. Plant practice has confirmed these figures, and the performance of the exchangers matches the design figures almost exactly.

Autoclave Feed System

From the surge tank immediately after the condenser side of the flash heat exchangers, the heated pulp is passed through centrifugal pumps in series to build up sufficient pressure to feed the autoclaves. There are four heavy duty 5x4 SRL-C pumps provided for this service, two of which are used to feed both lines of the autoclaves. The other two pumps are spare equipment.

The pumps do an exceptional job. Because these pumps are rubber-lined, their suppliers would not guarantee satisfactory service when pulp was pumped at a temperature over 180°F, but even at temperatures up to 210°F they have given excellent performance—except for one condition: it has been found that for operation under such conditions the amount of gland solution used is high, causing excessive dilution in the autoclaves and thus cutting down the retention time. If this excessive dilution from gland solution could be eliminated, performance of the pump would be perfect.

The pumps discharge through separate flow con-

trollers and control valves to the two lines of autoclaves. Each flow controller is a Fischer & Porter Ratosleeve Flowrator meter connected to a Fischer & Porter Magnabond pneumatic transmitter which operates a Fischer & Porter controller which controls a Mason-Neilan No. 737 control valve on the pump discharge.

When the flow controllers are set at any desired rate, all other float controllers, e.g., on autoclave discharge, will reset their rate automatically to feed the same quantity. Sometimes lag results, but not for longer than it takes to stabilize the flow through the autoclaves.

Control Valves

There are altogether 14 control valves handling flow through the flash heat exchangers, through the autoclaves, and from the discharge of the autoclaves, and these gave considerable trouble when the plant was started. The valves, all of the Mason-Neilan No. 737 diaphragm control type, had to operate under pressure drops of 80 to 100 lb. Plugs and seats of many different types were tried, but none stood up to the terrific duty until plugs and seats equipped with tungsten carbide inserts were used. Although these are very expensive, they have lasted well under the abrasive pulp. Previously control valves sometimes wore out after only 20 hr of service, but some of the tungsten carbide seats and plugs have seen over a year of service to date.

Acknowledgment

The authors wish to thank the Directors and Management of Eldorado Mining & Refining Ltd. for permission to publish this paper.

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Technical Note

Comminution as a Chemical Reaction

by A. M. Gaudin

IT is only in recent years that substantial progress has been made in developing a physico-chemical picture of the solid state. The molecular concept, so useful in dealing with gases, was naturally carried over to the field of crystalline solids; it has resulted in the firm implanting of erroneous concepts that only now are being eradicated successfully. Two simply written and effective books on the subject are *Crystal Chemistry by Stillwell*[1] and *An Introduction to Crystal Chemistry* by Evans.[2] A more complete treatment of the subject is available in a book by Wells.[3] The monograph by Hückel[4] also touches on a subject most easily perceived by reference to the brief introduction by Bragg,[5] that master of the field. These texts make it clear that while some solids are built of molecules, many are built of ions, others of atoms connected in the form of giant molecules, and still others of cations and electrons. The various lattices in which these entities are systematically arranged, the joint use of several of these entities, and the transitional character of some of the bonds make for the great variety of crystalline solids.

The purpose of this paper is to point out a most important corollary of present views on the structure of solids. In this connection the classification of solids in Table I is helpful.

Atomic crystals are those formed by the noble gases, e.g., helium and argon. They are soft, sublime at very low temperature, of very low specific gravities, and not encountered in ores.

Molecular crystals are uncommon among inorganic materials, common among organic materials. Typical examples from both inorganic and organic fields are sulphur, iodine, naphthalene, benzene, and carbon tetrachloride. These crystals are soft and have low specific gravities; where the molecules are small, the sublimation temperature is low.

A. M. GAUDIN, Member AIME, is Richards Professor of Mineral Engineering, Massachusetts Institute of Technology, Cambridge, Mass. Manuscript, Sept. 27, 1955. TN 273B.

Filament and sheet crystals are rare. They are typified by elemental selenium and elemental arsenic, respectively. Graphite and molybdenite come near being sheet crystals. These crystals are soft in some directions, tough in others, sublime at various temperatures.

Diamantine crystals, typified by diamond, are very few in number, stable at high temperatures, and extremely hard.

Table I. Classification of Crystals

Type	Description	Crystal
1	Uncharged single atoms, sharing no electrons	Atomic
2	Uncharged groups of atoms sharing electrons within the group, but not between	
	a) groups finite in all dimensions	Molecular
	b) groups infinite in one dimension	Filament
	c) groups infinite in two dimensions	Sheet
	d) groups infinite in all dimensions	Diamantine
3	Charged single atoms, sharing no electrons	Simple ionic
4	Charged groups of atoms, electrons being shared within the groups, but not between groups, the arrangement being such that	
	a) structures of zero dimension are formed	Complex ionic
	b) linear structures are formed	Fiber
	c) planar structures are formed	Layer
	d) block structures are formed	Framework
5	Positively charged atoms permeated by an electron gas	Metallic

Ionic crystals are common. Most salts, acids, and alkalies belong in the two classes of ionic crystals; examples are rock salt, fluorite, calcite, and anglesite. The salts, acids, and alkalies that do not belong in these classes are more properly regarded as transitional between ionic crystals, framework crystals, and diamantine crystals, e.g., ice and quartz.

Fiber crystals are relatively uncommon mineralogically speaking, but common in the fields of living processes. Examples are asbestos, silk, cellulose, and wool. Many fiber crystals are so little known even now that their crystallinity may be doubted.

Layer crystals, among the more interesting and useful of solids, include a wide variety of substances

that differ greatly from each other according to the structural cause of the layering. They include many organic compounds such as fatty acids, fatty alcohols, and amines, sheet silicates such as micas and clay minerals, as well as a few inorganic solids such as boric acid.

Framework crystals are common in the field of mineralogy (many silicates).

Metallic crystals, which complete the roster of crystalline solids, include all metals.

Like all classifications, Table I is idealized in that it does not bring out the many instances of transitional structures. It is not practicable to discuss these structures without expanding considerably the scope of this essay, but their existence and importance might well be underscored.

It is clear that the classification of crystals presented in Table I is based on one or on a combination of the following types of association: 1) juxtaposition of uncharged atoms; 2) juxtaposition of ions —electrovalent bond; 3) pooling of electrons by atoms—covalent bond; and 4) juxtaposition of cations and electrons.

Leaving out of consideration the fourth arrangement, which is represented only in metals, it is clear that the other three types in their various permutations, combinations, and gradations can result in great variety of properties. The first arrangement, which utilizes only so-called residual or van der Waals' forces, may well be regarded as nonchemical or as physical, while the other two, which utilize much stronger forces, can well be viewed as *chemical*.

For the purpose of this discussion, a chemical act will be defined as the rupturing of a covalent bond, or of an electrovalent bond and/or the formation of a new electrovalent or covalent bond. This definition includes, of course, such familiar processes as metathesis and chemosorption, as well as certain forms of distillation, condensation, melting, and dissolution. It does not include other familiar processes such as physical adsorption and certain forms of distillation, condensation, melting, and dissolution.

It may seem strange to consider distillation as essentially different in sundry cases, but contrast, for instance, the sublimation of benzene to that of diamond. In the first instance, unaltered C_6H_6 molecules pass from the crystalline to the gaseous state, while in the second instance individual, highly reactive carbon atoms are to be emitted.

Likewise, comminution which may appear at first to be the same process in all cases may really involve the parting of atoms that are connected in one of the ways described above. Where comminution connotes the severance of an ionic bond or of a covalent bond, a chemical reaction has taken place. Apparently comminution of Type 5 solids is virtually unrealizable.

What is still more significant is that the atoms at the new surface had been attached before and must seek new attachments at the earliest opportunity. In other words, the surfaces produced by comminution breaking across a crystal are extremely reactive, and this reactivity is extremely localized. At the moment of its formation, a bit of new surface in an erstwhile ionic or covalent crystal (e.g., types 2d, 3, 4a, 4d) must be a *free radical* in the sense in which the term in used in organic chemistry. Conversely, new surface formed in layer, fiber, sheet, and filament crystals may fail to have the properties of a free radical provided the plane of fracture separates atoms previously held to each other by residual forces only, and molecular crystals must fail to yield free radical surfaces.

Comminution in vacuo leads to production of surfaces whose reactivity can be satisfied only by reattachment of fragments to each other. Except in the case of extremely fine fragments (a very few atomic diameters in size) the probability of a mutual *fit* of the fragments is remote, and widespread occurrence of *cold welding* should not be anticipated. In the case of extremely fine fragments, cold welding possibly plays some part. This perhaps sets a limit to the abundance of extremely fine particles in a comminuted product.

Comminution in an inert gas probably differs from the idealized case just mentioned because of physical adsorption of gas molecules on the new surfaces, but this is not known.

In a reactive gas, such as moist air, it may be believed that the physical adsorption of water is probably immediately followed by chemosorption of ions from the water. The situation is then similar to that which arises as a solid is comminuted in water, in that the fresh surfaces are fresh no longer. This chemosorption of hydrogen and hydroxyl ions involves relatively large thermal effects. Any attempt at measuring the efficiency of comminution by procedures involving thermal changes should take into account the necessity for complete dehydration of the grinding atmosphere. It may even be necessary to conduct the measurements in a high vacuum.

If the chemosorption of hydrogen and hydroxyl ions on freshly broken surfaces is conceded, it goes without saying that the chemosorption of other ions must be conceded, whether these ions are intentionally added, as, for example, flotation agents, or unintentionally provided by the substance of the grinding machine, for example, ferrous ions, or whether these ions are provided by other solids that are being broken simultaneously. It will thus be clear that a large train of consequences flows from the initial appraisal of comminution as a chemical reaction—a train of consequences of great practical importance in chemical and metallurgical engineering.

Almost no work has been done in this field, largely because practice has been to grind in a water slurry or in air. Yet it would seem that the field has much to offer both in fundamental and applied areas. The pioneer who will study comminution of crystals of various types in a fluid of controlled composition or in a vacuum and who will correlate the various effects obtained with the crystal structure of the solid and the chemical attributes of the fluid is bound to find many interesting and useful data.

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Correction

In the April 1955 issue: TP 4012A. Mining Technology—Outlook for the Future. By E. D. Gardner. On p. 370, col. 1, par. 4, the first sentence should read: In addition to the solid materials moved, 318 million tons of petroleum and 176 million tons of gas were produced in 1953.

The Petrographic Composition of Two Alabama Whole Coals Compared to the Composition Of Their Size and Density Fractions

by Reynold Q. Shotts

CHEMICAL methods, based on the relative rates of oxidation of fusain, bright coal, and dull coal by nitric acid, have been devised to determine these coal components.[1-4] Results obtained by oxidation methods for fusain have been checked against results obtained from microscopic methods[5, 6] on duplicate samples of the same coals, but to the author's knowledge this has not been done for bright and dull coal components. For this reason it is not certain that the two methods of analysis identify essentially the same chemical or physical units. It would be highly desirable to see results of the application of both methods to duplicate samples, but in the absence of any such data the author has attacked the problem indirectly.

From the U. S. Bureau of Mines samples were obtained of three Alabama coals which the USBM had analyzed optically and reported on over the past 30 years. These samples were subjected to analyses by oxidation rate methods. Results of this work, and comparisons with the USBM analyses, have been published.[4] This was the first indirect approach to the problem. The present report attempts a second indirect approach by way of *internal* validation.

By nitric oxidation samples of two whole coals were carefully analyzed for fusain, bright coal, and dull coal. One coal was analyzed in duplicate. Duplicate portions of each of the coals were divided into three density fractions by means of heavy liquids. A duplicate portion of one of the coals was divided by sieving into three size fractions. Each fraction was analyzed by oxidation and its percentage composition calculated in terms of fusain, bright coal, and dull coal.

Because the weight percent of each fraction was known, a material balance calculation for the whole coal was also made. The resulting reconstituted analysis of the whole coal could be compared to that determined by direct analysis. In addition, specific reaction rate constants were determined for each component and for each whole coal or fraction.

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Discussion on this paper, TP 4040F, may be sent (2 copies) to AIME before Aug. 31, 1955. Manuscript, Nov. 12, 1954.

Arbitrary *reactivity indexes* were calculated by dividing by 100 the sum of the products of the percent of each component in the coal and its specific reaction rate constant. The resulting figure was an average reactivity index for each coal or fraction. Weighting the reactivity indexes for each fraction by the percent of the fraction in the coal gave a reactivity index for each whole coal which could be compared to that calculated directly from the whole coal analysis. If oxidation analyses really delineate definite physical entities within the coal, or even definite groups of similar entities, reconstituted analyses calculated from fraction analyses should check closely those made of the whole coal.

It probably is true that optical methods identify and describe a greater variety of components than do chemical methods and that variations are wide in the appearance and quantity of those components identified optically. Chemical methods based upon differences in oxidation reaction rates would of necessity be less discriminating, as between similar components, than would optical methods.

The procedures followed for oxidizing the samples, analyzing the residues, plotting and calculating the percentage of each component, and calculating its specific reaction rate constant have been fully described.[1-3]

In brief the method originally proposed by Fuchs et al.[1] for the determination of fusain consists of the oxidation of small samples of coal in boiling 8N nitric acid in a condenser-fitted flask. After boiling for periods of ½ to 4 hr, the unoxidized residue is filtered and washed. The washed residue is treated with normal sodium hydroxide, diluted, and allowed to stand for several hours. The resulting brown liquor is removed, and the filtered residue dried, weighed, ignited, and weighed again. The ash-free residue is expressed as a percent of original dry, ash-free coal. The percent residue is plotted against time, and the extrapolation of this line to zero time gives the percentage of dry ash-free fusain present in the original sample.

The shape of the resulting time plots has been explained[1] by the assumption that they are the result of two different types of reaction, the first part representing a first order reaction with rate a func-

tion of concentration, and the second or straight portion reflecting a zero order reaction with the rate independent of concentration.

Chemical and physical properties of the two coals used, and of the prepared fractions of each, are shown in Table I. Both coals were of medium volatile bituminous rank, the Pratt coal being of slightly higher rank.

The sample of Fairview bed coal was obtained from the USBM, for work reported previously.[4] For an Alabama coal it was fairly high in both ash and sulphur. The data from Table I on both the coal and its density fractions indicate the following: 1) *Free* pyrite made up about one quarter of the sulphur, being concentrated in the small, sink-1.59 fraction. 2) There was little rock in the sample because the sink-1.59 fraction was small and contained only 28.6 pct ash. 3) The rank of the sink-1.59 fraction was fairly high. This was partly due to high fusain content, as shown in Table II. 4) There was a distinct increase in the rank of all fractions, with increasing density. 5) The lightest fraction had considerably the larger heating value.

The Pratt bed coal came from the Edgewater mine of the Tennessee Coal, Iron & Railroad Div. of U. S. Steel Corp. The gross sample was a 2-ton lot of mine run coal. The sub-sample used was a grab sample from this lot and not necessarily representative. The high ash content of the raw coal was due to machine mining. The analyses justify the following conclusions: 1) That much rock was present is shown by the large size and very high ash content of the sink-1.55 fraction. The high ash of the plus No. 16 size fraction indicated the same. 2) As shown by the values for these items in the float-1.28 fraction, inherent ash and organic sulphur were low. 3) The whole coal and its fractions, except sink-1.55 fraction, were strongly swelling. This property is consistent with its use for coke-making. 4) The non-swelling character of the sink-1.55 fraction was due to its high ash and high fusain content.[7] 5) Neither size nor density separation effected any great differences in the rank of the fractions. Such increase as did occur was more clearly indicated by free swelling index than by unit coal fixed carbon content.

The percentage of each component and its reaction rate constant are shown in Table II. Figs. 1-3 show the results of the first-order oxidations in terms of bright and dull coal. Figs. 4, 5 show the zero-order oxidations of the fusain-component of each coal and fraction. Table II also contains percentages of bright and dull coal calculated to a fusain-free basis.

Petrographic Composition of Coals and Fractions

Assuming for the present that oxidation analyses do delineate actual petrographic components, the following generalizations may be made concerning the data in Table II.

1) Fusain, as is usually the case, was concentrated in the heavy density fractions of both coals.

2) The size separation of Pratt coal was not effective in concentrating fusain. Indeed, no size fraction analyzed quite as high in fusain as the whole coal.

3) The quantity of the bright coal component ($C_{e\text{-}1}$) of Fairview fractions decreased with increasing fraction density, but the amount of dull coal ($C_{e\text{-}2}$) was a maximum in the intermediate fraction. On a fusain-free basis, however, the quantities of dull coal were very nearly the same for the two heavier fractions.

4) For concentrating the bright and dull fractions of Pratt coal size separation was not nearly so effective as density separation. Bright coal content decreased with both increasing size and increasing density, in the same direction as the increase in rank shown in Table I.

5) The sink-1.55 fraction of Pratt coal constituted only 9.5 pct of the organic matter of the sample and consisted wholly of dull coal and fusain.

6) In both whole coals the specific reaction rate constant of the fusain was low. The author has previously observed but has published no comment upon the fact that the reaction rate constant of the fusain content of density fractions tends to decrease as the percent of fusain decreases. A plot of C_f against K_f illustrates this clearly except that the reactivity of the fusain in the fraction having the maximum fusain content was, for both groups of density fractions, just a little smaller than that of the intermediate fraction. Results of a large number of closely graded fractions might show that the specific reaction rate for fusain tends to level off with increasing fusain content.

7) The bright coal components of the various fractions of Pratt coal did not differ widely in specific reaction rate constant.

Table I. Approximate Analyses, Free Swelling Indexes, and Weight Percentage of Each Fraction Oxidized

Sample No.	Fraction	Wt, Pct	Analysis, Pct: Air Dry Basis: M	A	VM	FC	S	Btu	Unit Coal Basis: FC	Btu	FSI
						Fairview Bed, Soot Creek Mine*					
172B	Original sample	100	0.8	8.9	25.9	64.4	2.3	13,630	72.5	15,300	7½
173B	Float 1.30	23.6	1.6	3.8	30.2	64.4	1.5	14,590	68.8	15,530	
174B	Sink 130-float 1.59	71.4	0.7	8.1	26.5	64.7	2.0	13,780	72.0	15,290	
175B	Sink 1.59	5.0	2.4	28.6	16.3	52.7	10.4†	**	83.3	**	
						Pratt Bed, Edgewater Mine*					
176B	Original sample	100	1.0	20.6	22.9	55.5	2.0	11,990	73.0	15,700	8½
177B	−50 mesh	12.3	1.2	17.2	24.2	57.4	2.1	12,420	72.6	15,570	8½
178B	−16 + 50 mesh	24.9	0.9	15.0	24.1	60.0	1.9	12,900	73.3	15,650	9
179B	+16 mesh	62.8	1.1	24.7	21.0	53.2	2.3	11,310	74.5	15,770	7
181B	Float 1.28	39.2	0.7	2.3	26.8	70.2	1.0	15,280	72.5	15,710	9+
182B	Sink 1.28-float 1.55	32.8	0.8	8.1	25.9	65.2	1.6	14,160	72.5	15,720	8½
183B	Sink 1.55	28.0	1.2	66.3	12.9	19.6	2.3	3,920**	74.2	14,680**	1‡

* Coal crushed to pass No. 4 sieve before separation.
** Ash and sulphur too high to obtain complete combustion in calorimeter. Values omitted or possibly too low.
† Calculated value.
‡ Button dumped without breaking but could not be handled.

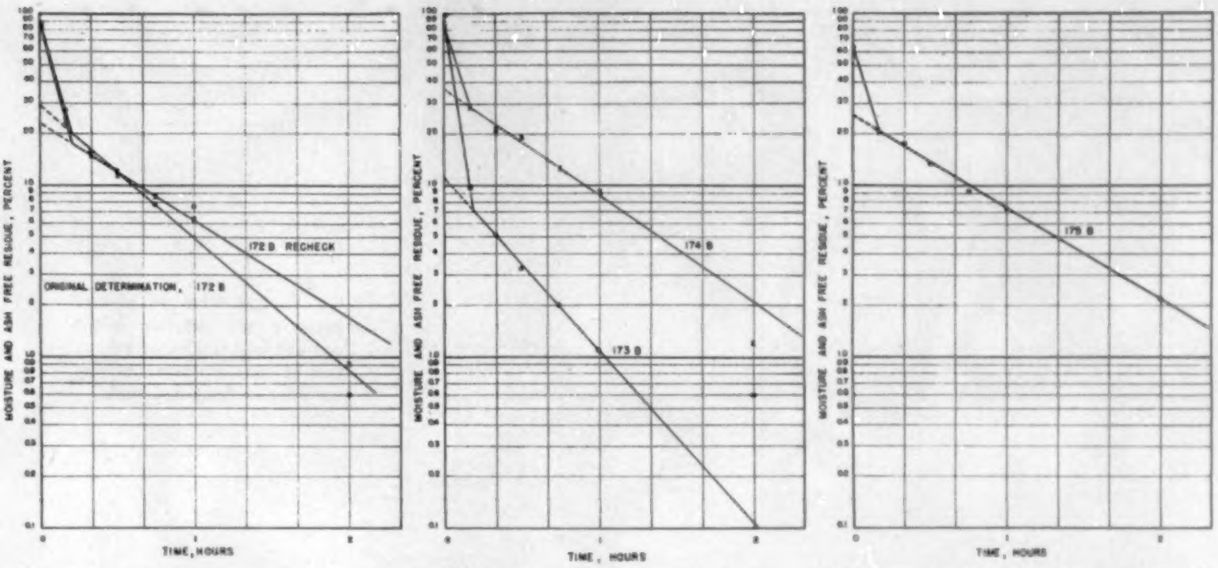


Fig. 1—Logarithm of percent moisture and ash-free bright and dull coal residue as a function of time, for Fairview bed coal and three of its density fractions.

8) The bright component of Fairview float-1.30 was by far the most reactive component of any fraction. The bright coal components of the two heavier fractions of this coal had similar values.

Whole Coal and Weighted-Fraction Composition

In Table II, duplicate oxidation rate analyses of Fairview coal are shown. Agreement between the two analyses was fairly good. The repeat analysis showed a slightly greater quantity of much more reactive fusain and a smaller quantity of less reactive dull coal than did the original analysis.

Table III repeats the percentages of the various components of the whole coals from Table II and shows the reconstituted analyses calculated from the size and density fractions and weighted by the percent of each fraction in the whole coal. The values are also shown on a fusain-free basis.

For Fairview bed coal the results of reconstituted and direct analyses gave surprisingly close agreement. Both fusain and dull coal contents were slightly higher than in either of the whole coal analyses. In the case of Pratt bed coal the analysis calculated from size fractions just about reversed the quantities of bright and dull coal and gave a low result for fusain. The density fractions gave a higher result for fusain but checks were good for bright and dull coals. On a fusain-free basis, the calculated percentages of bright and dull components checked the directly determined values a little more closely. On the basis of only one size fraction, it appears that density fractions are superior to size fractions for making a weighted average check, probably because for the particular coals used the separation of petrographic components was much sharper.

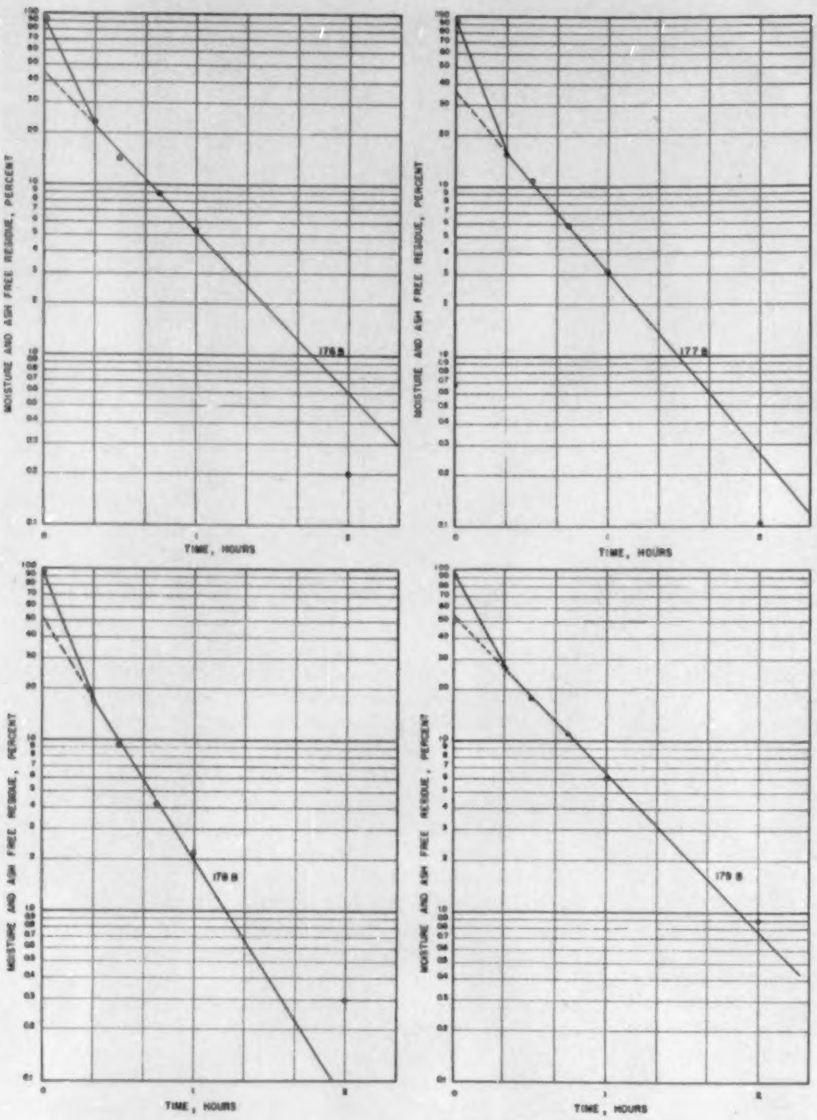
It is obvious that some actual differences should be expected between the results of analyses of duplicate lots of the same coal. In addition to actual chance differences in composition, whole coals and the lighter fraction of each reacted so rapidly during the first few minutes of oxidation that accuracy could not be as high as that of proximate analyses.

Mineral matter correction formulas were not applied in calculation of the true organic matter content of the original samples or of the residue remaining after oxidation, although they should have

Table II. Petrographic Analyses (Chemical Method) and Specific Reaction Rate Constants of the Whole Coals, Density Fractions of Fairview and Pratt Bed Coals, and Size Fractions of Pratt Bed Coal

Fraction or Constant,	Fairview Bed					Pratt Bed						
	Whole Coal		Density Fractions				Size Fractions			Density Fractions		
Pct or Pct per Hr	172B	172B*	173B	174B	175B	176B	177B	178B	179B	181B	182B	183B
C_f	12.3	13.3	2.1	15.8	38.4	5.7	5.4	3.4	5.2	1.3	8.3	15.3
C_{c-1}	59.7	64.7	87.2	47.7	36.1	49.3	58.6	45.6	40.8	92.3	38.7	0.0
C_{c-2}	28.0	22.0	10.7	36.5	25.5	45.0	36.0	51.0	54.0	6.4	53.0	84.7
K_f	0.50	0.92	0.23	1.63	1.46	0.50	0.53	0.24	0.23	0.13	0.90	0.76
K_{c-1}	7.00	7.44	13.78	6.38	6.55	4.31	5.29	4.79	3.77	5.15	3.96	
K_{c-2}	1.90	1.62	2.25	1.41	1.23	2.16	2.45	4.63	2.13	1.39	2.29	1.53
Calculated to a Fusain-Free Basis												
C_{c-1}	68.2	74.5	89.1	55.7	58.5	52.3	61.9	47.2	43.2	95.5	57.8	0.0
C_{c-2}	31.8	25.5	10.9	44.3	40.5	47.7	38.1	52.8	56.8	6.5	42.2	100.0

* Duplicate analysis.
Key to symbols for components and specific reaction rate constants:
C_f = Fusain, pct.
C_{c-1} = Bright (or more reactive) coal, pct.
C_{c-2} = Dull (or less reactive) coal, pct.
K_f = Specific reaction rate constant, fusain, pct per hr.
K_{c-1} = Specific reaction rate constant, bright coal, pct per hr.
K_{c-2} = Specific reaction rate constant, dull coal, pct per hr.



OPPOSITE PAGE

Fig. 3—Logarithm of percent moisture and ash-free bright and dull coal residue as a function of time for three density fractions of Pratt bed coal.

LEFT

Fig. 2—Logarithm of percent moisture and ash-free bright and dull coal residue as a function of time, for Pratt bed coal and three of its size fractions.

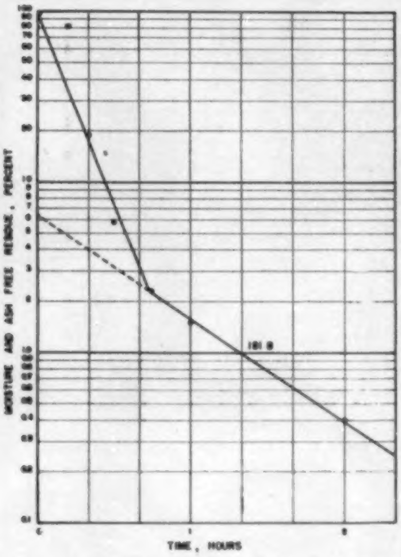
been so applied to secure greatest accuracy. The composition of the ash of the various fractions undoubtedly varied considerably. In the absence of data concerning differences in mineralogical composition of the ash of the various fractions, however, the less accurate ash correction formula was used. Possible catalytic effects, differences in ease of wetting, and differences in the rate of heating of coal-nitric acid mixtures to boiling are some of the unassessed factors that might contribute to variable results in the tests.

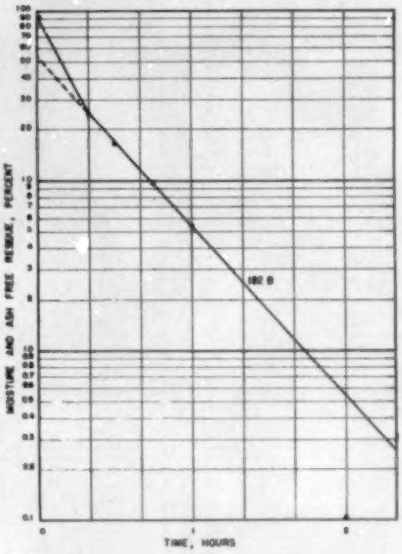
In spite of the large number of possible uncontrolled or uncontrollable factors, the author believes that the agreement between analyses of the whole coals and the reconstituted whole coal compositions calculated from the separate analyses of the fractions was sufficient to provide a basis for the conclusion that the dull coal, bright coal, and fusain fractions identified and estimated by the nitric acid oxidation method do exist. No doubt much material in the coal is intermediate or gradational, going first with one and then with another fraction as a sample

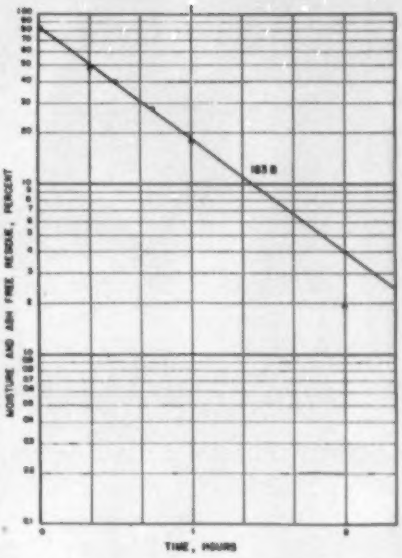
Table III. Analyses of Whole Coals* and Calculated Analyses Reconstituted from Fraction Analyses and Percent of Each Fraction in the Whole Coal

	Fairview Bed						Pratt Bed								
	Whole Coals		Density Fractions			Total	Size Fractions				Total	Density Fractions			Total
Fraction	172B	172B**	173B	174B	175B	100	176B	177B	178B	179B	100	181B	182B	183B	100
C_f x pct frac.†	(12.3)	(13.3)	49.6	1128.1	192.0	13.7	(5.7)	66.4	84.7	326.6	4.8	51.0	272.2	428.4	7.5
C_{c-1} x pct frac.	(59.7)	(64.7)	2057.9	3402.8	180.5	56.4	(49.3)	720.8	1135.4	2562.2	44.2	3618.2	1269.4	0.0	48.9
C_{c-2} x pct frac.	(28.0)	(22.0)	252.5	2606.1	127.5	29.9	(45.0)	442.8	1269.9	3391.2	51.0	250.9	1738.4	2371.6	43.6
Calculated to a Fusain-Free Basis															
C_{c-1} x pct frac.	(68.2)	(74.5)	2102.8	3977.0	292.5	63.7	(52.3)	761.4	1175.3	2713.0	46.5	3665.2	1895.8	0.0	55.6
C_{c-2} x pct frac.	(31.8)	(24.5)	257.2	3163.0	202.5	36.3	(47.7)	486.6	1314.7	3567.0	53.5	254.8	1384.2	2800.0	44.4

* Numbers in parentheses are directly determined values.
** Duplicate sample.
† The percent of each size or density fraction of each coal may be read from Table I.







is separated by any method that is sensitive to real physical differences between the lumps. That the physical differences reflect chemical differences with regard to ease of oxidation seems logical also. Perhaps it is true that some dull coal is duller than other dull coal and some bright coal is brighter, or more reactive, than other bright coal, but there seem to be some real, fairly sharp differences between these two components in any given coal.

As revealed by the microscope and described in many publications, the petrographic composition of bituminous coals appears to be more variable than the simple bright coal—dull coal—fusain composition from oxidation analyses would indicate. Indeed, the variations in specific reaction rate constants of the various components of the separate size and density fractions, Table II, suggest a not too simple composition for the original whole coals.

The conclusion is practically inescapable that differences between petrographic components are due to: 1) differences between pre-burial conditions to which the separate components were subjected; 2) differences in types of plant matter contributing to each component; or 3) differences in early post-burial conditions. If such were the case, although tiny portions of one component might differ substantially from other tiny portions, the general composition or structure of that component might cause its particles to suffer a uniform rate of attack by nitric acid, under given conditions, while another component, under the same conditions, might be attacked more or less rapidly than the first one. Fuchs et al.[1] demonstrated, for example, that the reaction between fusain and nitric acid is zero-order, while bright and dull components exhibit first-order rates of reaction with the same reagent.

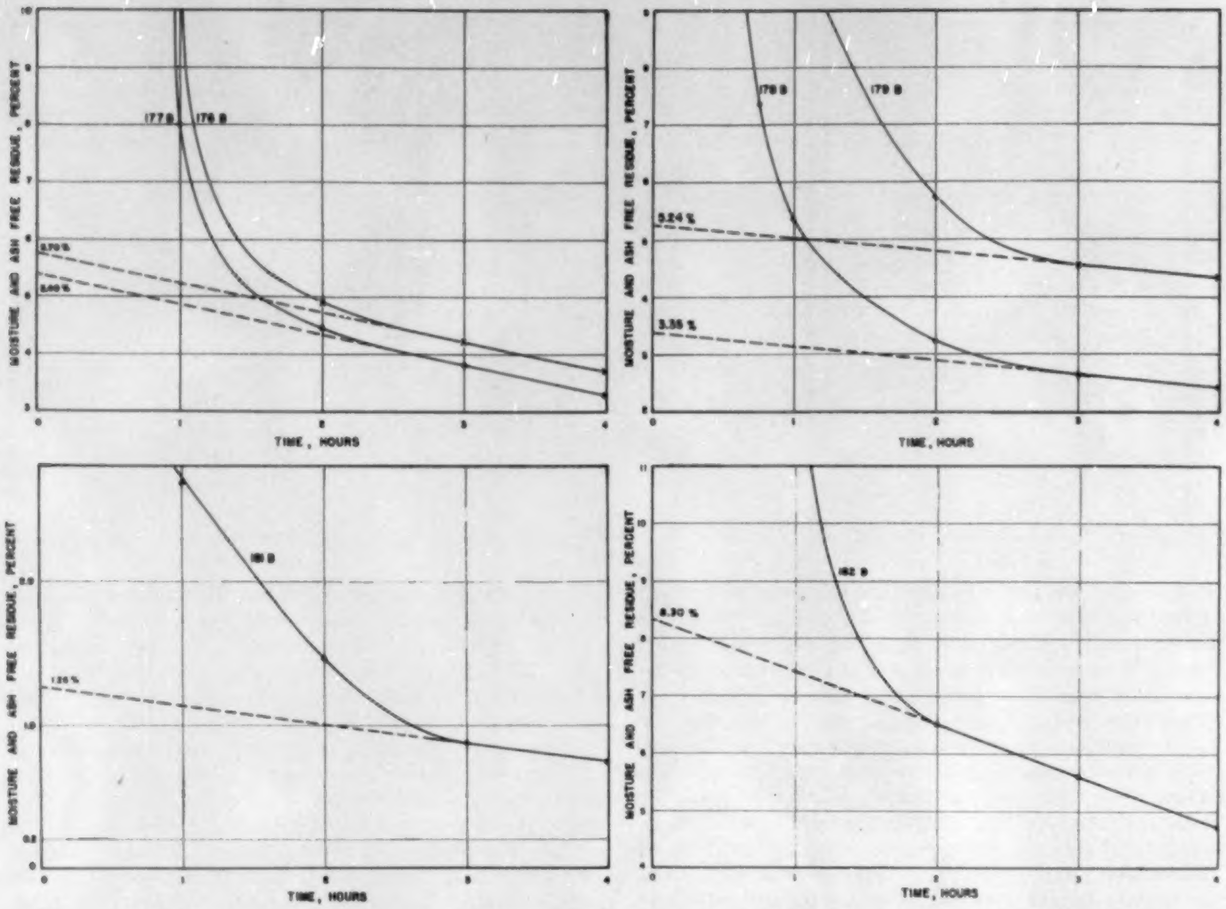
Reactivity Indexes

Table IV shows indexes of reactivity found simply by multiplying the percent of each component in the coal, or fraction, by its specific reaction rate constant, adding the products, and dividing the sum by 100. The quotient has no actual physical meaning and is expressed in no physical units that are

Table IV. Indexes of Reactivity (R.I.)* for Each Whole Coal and for Each Fraction Oxidized and Composite Indexes for Each Coal Reconstituted from Its Fractions†

		Fairview Bed					Pratt Bed						
		Whole Coal		Density Fraction			Size Fraction				Density Fraction		
Line No.	Fraction	172B	172B**	173B	174B	175B	176B	177B	178B	179B	181B	182B	183B
1	$C_f \times K_f$	6.15	12.24	0.48	25.75	56.06	2.85	2.86	0.82	1.20	0.17	7.47	11.63
2	$C_{c-1} \times K_{c-1}$	417.90	501.46	1201.6	304.33	246.46	212.48	309.90	218.42	153.82	475.35	153.25	0.00
3	$C_{c-2} \times K_{c-2}$	55.72	35.64	24.08	51.47	31.37	97.20	88.20	236.13	115.02	8.90	121.40	129.59
4	Total/100 (R.I.)	4.80	5.49	12.26	3.82	3.24	3.03	4.01	4.55	2.70	4.84	2.82	1.41
5	R.I. x 23.6 pct	289.34											
6	R.I. x 71.4 pct	272.75											
7	R.I. x 5.0 pct	16.20											
8	Total/100 (R.I.)	5.77	5.77										
9	R.I. x 12.3 pct						49.32						
10	R.I. x 24.9 pct						113.30						
11	R.I. x 62.8 pct						169.56						
12	Total/100 (R.I.)						3.32						
13	R.I. x 39.2 pct						189.73						
14	R.I. x 32.8 pct						92.50						
15	R.I. x 28.0 pct						30.48						
16	Total/100 (R.I.)						3.22						
	Calculated from Analyses to a Fusain-Free Basis												
17	Whole Coals (R.I.)	5.41	6.00				3.28						
18	Size fraction (R.I.)						3.46						
19	Density fraction (R.I.)	6.16	6.16				3.42						

* R. I. = (CxK)/100.
** Duplicate sample.
† R. I. = (Index of each fraction times weight percent of fraction)/100.



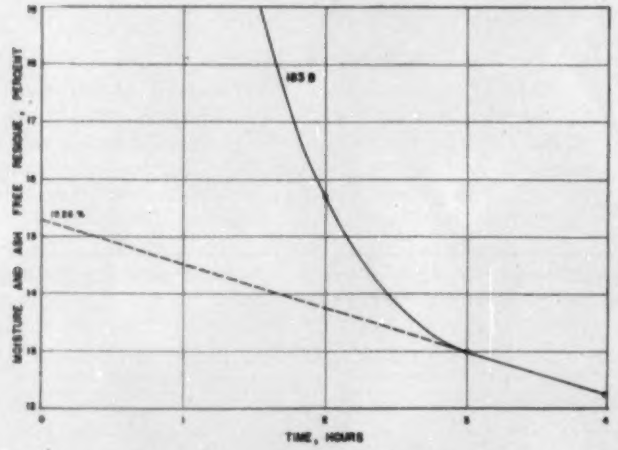


Fig. 4—Total residue as a function of time for Fairview bed coal and its fractions.

susceptible to dimensional analysis unless they be in *percent-per-hour,* the same units as those of the specific reaction rate constants. Even so, the units are not self-consistent, as fusain oxidizes by a zero-order law and the other two components by first-order laws. The quotient should, however, be roughly a mean or proportional specific reaction rate constant for the whole coal, had the coal been a pure or chemically homogeneous substance having that particular reactivity, rather than a mixture. In Table IV, the whole coal indexes shown were calculated by combining the fraction indexes in proportion to the percent of each fraction present in the coal. Reactivity indexes of this type have been calculated before, and it has been shown that these indexes may be in the same order as the ranks of the coals analyzed.[4] The differences between corresponding reactivity indexes, as shown in Table IV, were not large. A study of Tables I and IV will show that the indexes for the fractions were also roughly in the same order as their ranks.

Reconstituted fraction reactivity indexes (lines 8, 12, and 16 in Table IV) were a little larger than direct whole coal indexes (line 4) in every case. When the results were calculated to a fusain-free basis, they were a little closer than when fusain was included (lines 17 to 19).

Conclusions

The results of these tests indicate that bright coal, dull coal, and fusain in bituminous coals react with nitric acid at different rates and that the bulk of each of the components reacts at a uniform rate.

That distinct components do exist, that they tend to concentrate, more or less, in different density or size fractions, and that they react essentially the same way toward nitric acid in the fractions as they do in the whole coal is shown by a "material balance" calculation from size and density fraction analyses. The resulting reconstituted petrographic compositions were very close to those obtained by analyzing the whole coal samples directly.

Weighted average reactivity indexes, calculated from whole coal analyses and from analyses of the size or density fractions, also checked each other closely and are probably in the same order as the rank of the coals. The coals examined in this work were too nearly the same rank to provide valid evidence on this point.

The results of this work and previous work published by the writer[3, 4] show that the percent of the

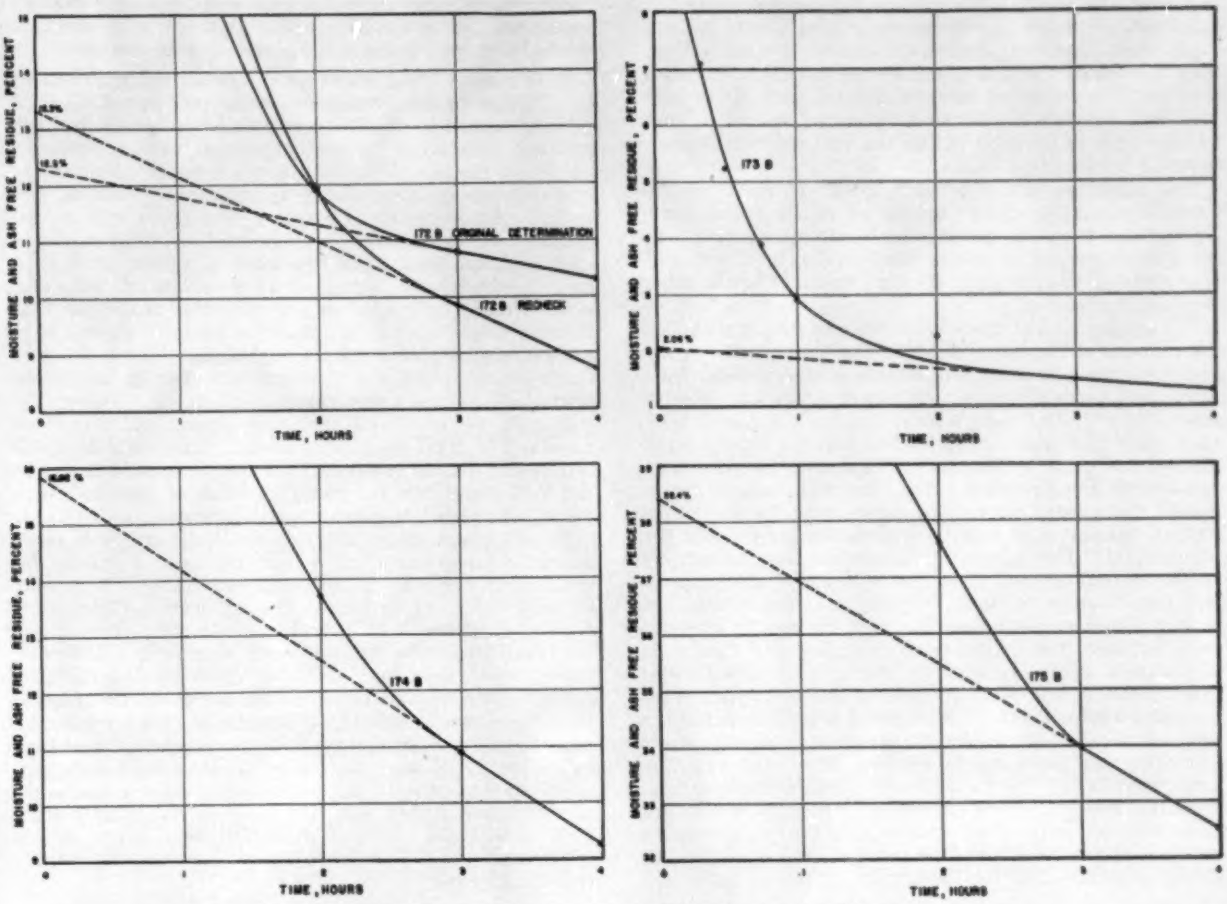


Fig. 5—Total residue as a function of time for Pratt bed coal and its fractions.

more reactive and less reactive components of a bituminous coal can be determined by nitric acid oxidation rate analyses and that the relative reactivities of the components can be compared with each other and with corresponding components of other bituminous coals. Further, the components determined chemically appear to correspond to the transparent, opaque, and fusain components seen under the microscope.

Acknowledgments

The major portion of this work was made possible by a grant from the University of Alabama Research Committee. Practically all the oxidations and many of the chemical analyses were made by J. D. Cowen, student analyst. The writer wishes also to thank Bryan Parks, of the USBM, for the samples of Fairview bed coal and Ralph Kirk, TCI Div., U. S. Steel Corp., for the sample of Pratt coal.

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DISCUSSION

Gilbert Thiessen *(Koppers Co. Inc., Pittsburgh)*—This paper is an extension of work in previous AIME Transactions 2 and 4. In the first article the conclusion was drawn that coals contained classes of materials which were oxidized at differing rates by nitric acid under certain specified conditions. It was speculated that the classes of materials which had different reactivities toward nitric acid corresponded to the petrographic components of coal. The second article attempted to correlate the materials as indicated by the wet oxidation with the petrographic components as estimated for same coals by another laboratory. In the reader's opinion the numbers (3), types (1), and general ranks (1) of coal compared were too small and the agreement too questionable to establish definitely a correlation between the oxidation residues and the microscopically estimated petrographic components. The present article attempts to establish further this correlation between chemically and microscopically determined components. For this purpose several coals were separated physically into fractions, the original coals and fractions analyzed, and the weighted average of the analyses of the fractions compared with the analysis of the original. The correspondence is good. This does not prove, however, that the components for which the coal was analyzed were the petrographic components; it proves that whatever components the whole coal was analyzed for could proportionately be found in the fractions. The results show that the method is consistent within itself; it does not show that the items segregated and estimated correspond to any other segregated and estimated materials.

In the reader's opinion, had coals of different types—such as splint, cannel, predominantly bright coal, predominantly dull coal other than splint, and coals of different ranks such as semi-bituminous, low-volatile,

high-volatile, and sub-bituminous coal—been studied in collaboration with a petrographic laboratory, as was done with the coals described in the second article, then we would have a much better basis for deciding whether the chemical method did, in fact, determine materials comparable to those estimated visually. This, I feel, needs to be done before the method can unquestionably be accepted.

The objective of the work is good. In most laboratories chemical methods would be much more easily carried out than the petrographic optical method, and the author should be encouraged to make further correlations of the results of his methods with other methods.

The reader would agree with the conclusion that "... the percent of the more reactive and less reactive components of a bituminous coal can be determined by a nitric acid oxidation rate analyses and that the relative reactivities of the components can be compared with each other and with corresponding components of other bituminous coals." The reader disagrees that the present article gives evidence that "the components determined chemically appear to correspond to the transparent, opaque, and fusain components seen under the microscope." This apparent correlation was the subject of the second article. It is not believed that the present paper adds to that correlation. Therefore, the reader also does not agree that "... the results of these tests indicate that bright coal, dull coal, and fusain, in bituminous coals, react with nitric acid at different rates and that the bulk of each of the components reacts at a uniform rate." No figures were given for the microscopically determined petrographic components and therefore there can be no data as to their reaction with nitric acid. In the reader's opinion these results indicate that there are components in coal which appear to react with nitric acid at different rates, and a relation might be established between the quantities of these materials and the quantities of materials which have recognizably different appearances under the microscope. I do not believe either that it was shown that the bulk of each component reacts at a uniform rate.

R. O. Shotts *(author's reply)*—The author appreciates Dr. Thiessen's thoughtful and generous review.

With regard to Dr. Thiessen's principal point that the entities delineated by the oxidation rate procedures have not been conclusively proved to be identical to microscopically determined petrographic entities, the author cannot choose but agree. The point will not be proved conclusively, one way or another, until someone uses both methods upon the same samples. If it is to be proved universally true, a wide variety of ranks and types should be compared. The author still feels that there is a relationship and that the series of papers does present a strong tie-up with regard to a broad designation such as *bright* and *dull* coal, but specific identification of all petrographic components is yet lacking.

It will be observed that the author, in all three papers, has tried to qualify broad statements by limitation to "bituminous coals." A lignite was included in the first paper but the range of rank of the coals oxidized, other than the lignite, was narrow.

Dr. Thiessen suggests that the bulk of each component does not react at a uniform rate. Perhaps the word *uniform* was an unfortunate choice. The very method itself is based upon the apparent second order type of oxidation rate for each component (zero order for fusain) and the fact that each plots with a different, but unique, slope on semi-log coordinates. As suggested in the second paper of the series (3), it may be that "the great rapidity of oxidation may mask the presence of matter of intermediate reactivity" and thus oxidation rates may be more complex than they appear. In that case the *apparent uniformity*, in the sense in which the author used the term, is not strictly true. Low rank coals (2) and oxidation with acids of low concentration (3) suggest these possible departures from uniformity.

Determining Depth of Faulting From Magnetic Field Intensity Measurements

by Otto W. Nuttli

THE magnetic method of prospecting is well suited to determination of faulting in the basement rock. In addition to establishing the horizontal position of the fault, it often furnishes valuable information concerning the depth and amount of faulting.

Consider a simple case of a vertical fault, represented in cross-section in Fig. 1. Let AA' represent the plane of observation (ordinarily the surface of the earth), and $BB'B''B'''$ the upper surface of the basement. Assume that the sedimentary rocks are nonmagnetic, so that the magnetic susceptibility of the material above the basement is zero. Let k indicate the susceptibility of the basement rock, σ the density contrast between it and the neighboring sedimentary rocks, and t the amount of vertical displacement.

Fig. 1 shows the material, indicated by cross-hatching, which gives rise to the magnetic anomaly. In most cases it can be assumed that t is small compared to the thickness of the sedimentary rocks. The semi-infinite, rectangular slab of rock of susceptibility k, density contrast σ, and thickness t may then be replaced by a semi-infinite sheet CC' of mass σt per unit area at depth z (the mean depth of the slab). Nettleton[1] states that this approximation results in an error of less than 2 pct for the computed gravitational field intensity when t is as great as $z/2$ and decreases rapidly for smaller values of t.

By a theorem of Poisson, the magnetic field intensity can be determined readily from the gravitational field. The theorem states that

$$W = (I/\gamma\sigma) \cdot (\partial U/\partial i)\, i_1 \quad [1]$$

where W is the magnetic potential associated with the structure, I is the intensity of magnetization which is assumed to have the direction of the inducing field, γ is the constant of gravitation, σ the density contrast, U the gravitational potential associated with the structure, i the direction of the inducing magnetic field, and i_1 a unit vector in that direction. The multiplication indicated in Eq. 1 is

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Discussion on this paper, TP 3989L, may be sent (2 copies) to AIME before Aug. 31, 1955. Manuscript, Sept. 15, 1954.

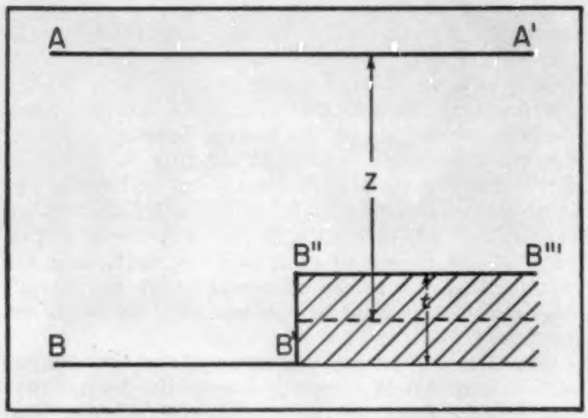

Fig. 1—Profile view of a two-dimensional, vertical fault.

the scalar or dot product of two vectors. Eq. 1 assumes that the structure is uniformly magnetized. This assumption is not always justified. However, there are methods of checking the validity of this assumption in individual field cases. One method, which requires both the horizontal and vertical components of the magnetic field intensity, will be described later in the paper. The other method, used by Garland,[2] employs both a magnetic and a gravity survey over the structure. It may be of interest to note that there are several fault structures in eastern Missouri which apparently satisfy the various assumptions that have been stated.

The components of the magnetic field intensity may be obtained by taking the partial derivatives of the magnetic potential. Thus

$$X = \partial W/\partial x \qquad Y = \partial W/\partial y \qquad V = \partial W/\partial z \qquad [2]$$

where V is the vertical and X and Y are mutually perpendicular horizontal components of the field intensity due to the structure.

Let the inducing field have an intensity F_0. Then $I = k F_0 = k(X_0 a + Y_0 b + V_0 c)$ where X_0, Y_0, V_0 are the components of the inducing field and a, b, c are unit vectors in the direction of the x, y, z axes, respectively. From Eqs. 1 and 2 it follows that

$$X = (k/\gamma\sigma)\,(X_0\,\partial^2U/\partial x^2 + Y_0\,\partial^2U/\partial x\partial y + V_0\,\partial^2U/\partial x\partial z), \qquad [3]$$

$$Y = (k/\gamma\sigma)\,(X_0\,\partial^2U/\partial x\partial y + Y_0\,\partial^2U/\partial y^2 + V_0\,\partial^2U/\partial y\partial z), \text{ and} \qquad [4]$$

$$V = (k/\gamma\sigma)\,(X_0\,\partial^2U/\partial x\partial z + Y_0\,\partial^2U/\partial y\partial z + V_0\,\partial^2U/\partial z^2). \qquad [5]$$

Eqs. 3, 4, and 5 are valid for any uniformly magnetized structure.

Let the strike of the fault make an angle α with the magnetic north. Also, let the y axis correspond to the strike of the fault. Then $\partial U/\partial y$ equals zero, and in addition, from Laplace's equation, $\partial^2U/\partial x^2 = -\partial^2U/\partial z^2$. Eqs. 3, 4, and 5 reduce to

$$X = (k/\gamma\sigma)\,(-X_0\,\partial^2U/\partial z^2 + V_0\,\partial^2U/\partial x\partial z), \qquad [6]$$

$$Y = 0, \text{ and} \qquad [7]$$

$$V = (k/\gamma\sigma)\,(X_0\,\partial^2U/\partial x\partial z + V_0\,\partial^2U/\partial z^2). \qquad [8]$$

It may be noted that $X_0 = H_0 \sin\alpha$, where H_0 is the horizontal component of the earth's magnetic field.

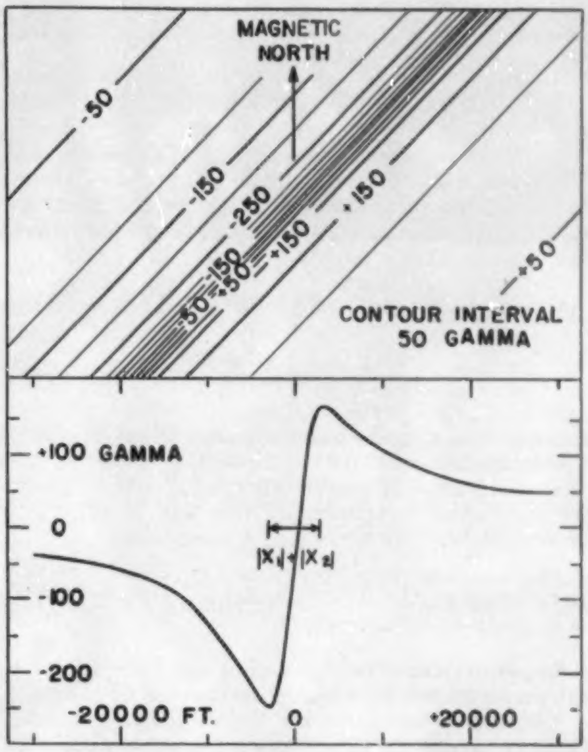

Fig. 2a (above)—Surface map of the vertical component of the anomalous magnetic field intensity.

Fig. 2b (below)—Profile at right angles to strike of the vertical component of the anomalous magnetic field intensity.

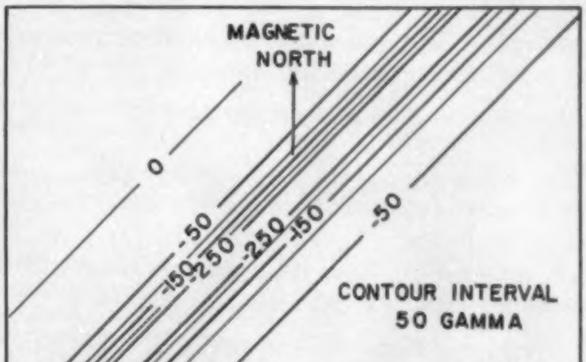

Fig. 3a (above)—Surface map of component of the anomalous magnetic field intensity measured with a horizontal magnetometer.

Fig. 3b (below)—Profile at right angles to strike of the anomalous magnetic field intensity measured with a horizontal magnetometer.

It can readily be shown that the vertical component of the intensity of the gravitational field of the fault satisfies the equation

$$\partial U/\partial z = 2\gamma\sigma t(\pi/2 - \tan^{-1} x/z). \qquad [9]$$

When Eq. 9 is differentiated and the appropriate values in Eqs. 6 and 8 are substituted, expressions result for the horizontal and vertical magnetic field intensity components over a fault. These expressions are

$$X = \frac{-2\,k\,t}{x^2 + z^2}\,(x\,H_0 \sin\alpha + z\,V_0) \qquad [10]$$

$$V = \frac{2\,k\,t}{x^2 + z^2}\,(-z\,H_0 \sin\alpha + x\,V_0). \qquad [11]$$

Since the horizontal magnetometer measures only the component of the horizontal portion of the anomalous field in the direction of magnetic north, the horizontal component of the field of the fault determined by the horizontal magnetometer is

$$H = X \sin\alpha = \frac{-2\,k\,t \sin\alpha}{x^2 + z^2}\,(x\,H_0 \sin\alpha + z\,V_0). \qquad [12]$$

Depth Rules: The horizontal distance between the maximum and minimum values of V or H makes it possible to compute the depth z. To establish these relationships, differentiate Eqs. 11 and 12 with respect to x and equate to zero. The roots of these equations will give the values of x for which V and H have their maximum and their minimum values.

The maximum value of V occurs when $x_1 = (z/V_0)\,(H_0 \sin\alpha + \sqrt{H_0^2 \sin^2\alpha + V_0^2})$. The minimum value occurs when $x_2 = (z/V_0)\,(H_0 \sin\alpha - \sqrt{H_0^2 \sin^2\alpha + V_0^2})$. Thus the horizontal distance between maximum and minimum values of V is

$$|x_1| + |x_2| = (2z/V_0)\,\sqrt{H_0^2 \sin^2\alpha + V_0^2}\,. \qquad [13]$$

The maximum value of H occurs when $x_3 = (z/H_0 \sin\alpha)\,(-V_0 - \sqrt{H_0^2 \sin^2\alpha + V_0^2})$ and the minimum value occurs when $x_4 = (z/H_0 \sin\alpha)\,(-V_0 + \sqrt{H_0^2 \sin^2\alpha + V_0^2})$. Thus the horizontal distance between the maximum and minimum values of H is

$$|x_3| + |x_4| = (2z/H_0 \sin\alpha)\,\sqrt{H_0^2 \sin^2\alpha + V_0^2}\,. \qquad [14]$$

From Eq. 13,

$$z = V_0\,(\,|x_1| + |x_2|\,)\,/\,2\,\sqrt{H_0^2 \sin^2\alpha + V_0^2}\,. \qquad [15]$$

From Eq. 14,

$$z = H_0 \sin\alpha\,(\,|x_3| + |x_4|\,)\,/\,2\,\sqrt{H_0^2 \sin^2\alpha + V_0^2}\,. \qquad [16]$$

Eqs. 15 and 16 furnish two independent expressions for the depth z in terms of quantities which can be observed in the field. However, from Eq. 14 it can be seen that if H_0 or α is small, $|x_3| + |x_4|$ is very large compared to z. This is undesirable, because the effect of the neighboring structures will then become significant. To avoid this difficulty, use the distance between the values of x for which H is one-half its minimum value. From Eq. 12 it can be shown that

$$|x_5| + |x_6| = (2\,z/V_0)\,\sqrt{H_0^2 \sin^2\alpha + V_0^2} \qquad [17]$$

where $|x_5|$ and $|x_6|$ are the values of x for which H is one-half its minimum value. If H_0 or α is small, the minimum value of H occurs approximately over the fault, where $x = 0$. The values of H will approach zero as $|x|$ becomes large.

Example: The following example illustrates the use and limitations of the theory developed above. Assume that there is a fault striking 45° west of north. Let the vertical displacement be 1000 ft, the depth to the upthrown side of the basement 2500 ft, the density contrast 0.5 gm per cm^3, the susceptibility of the basement rock 0.01 cgs units, and the vertical and horizontal components of the earth's magnetic field intensity 0.6 and 0.2 oersteds, respectively.

Figs. 2 and 3 show the components of the anomalous magnetic field intensity due to the fault structure which would be measured with the vertical and horizontal magnetometers, respectively. The problem is to determine as much as possible about the structure from these observations.

Figs. 2a and 3a show that the structure is two-dimensional and that it strikes 45° east of north. Fig. 2b indicates a fault structure; in addition, $|x_1| + |x_2| = 6000$ ft. Thus from Eq. 15, $z = 3000$ ft. Fig. 3b shows the limitations of Eq. 14. The maximum value of H is not sharply defined, so that the value of $|x_3| + |x_4|$ cannot be determined with any reliability. However, $|x_5| + |x_6|$ can be readily determined as 6000 ft. From Eq. 17, $z = 3000$ ft. The agreement between the values of z would indicate, for an actual field problem, that the assumption of a uniformly magnetized fault is a good one. It is not possible to determine k or t uniquely from the field data, since an infinite number of combinations of these can satisfy the data. However, in many cases it is possible to estimate the order of magnitude of k. Then, from Eqs. 11 and 12, a value of t may be estimated.

Conclusions: The horizontal distance between the maximum and minimum values of V, the vertical component of the magnetic field intensity, makes it possible to compute readily the mean depth to the faulted surface by using Eq. 15. The assumption of uniform magnetization can be verified by use of the horizontal distance between the points for which the component of the magnetic field measured with a horizontal magnetometer along a line at right angles to the strike of the fault has one-half its minimum value. This distance, when substituted into Eq. 17, gives an independent expression for the mean depth z.

If the fault strikes almost north-south, there will be no measured horizontal anomaly, as can be seen from Eq. 12, since $\sin\alpha = 0$. It is possible, however, to compute the expected vertical component of the magnetic field intensity from observed gravity data, as indicated by Garland.[2] Agreement between the computed and observed values of the vertical component of the magnetic intensity verifies the validity of the assumption of a structure of uniform magnetization and uniform density contrast. One difficulty peculiar to the gravity data is the necessity of making terrain corrections, which may be large in areas of rugged topography.

Although a unique value of z can be determined, it is not possible to obtain unique values of k and t from the field intensity observations.

References

[1] L. L. Nettleton: *Geophysical Prospecting for Oil*. McGraw-Hill Book Co., New York, 1940.
[2] G. D. Garland: Combined Analysis of Gravity and Magnetic Anomalies. *Geophysics*, 16, 1951, pp. 51-62.

aime news

Northwest Conference Attracts Nearly 400 Persons to Spokane

Nearly 400 persons attended the AIME Pacific Northwest Conference in Spokane, Apr. 28 to 30, 1955. Two hundred eighty-two persons registered for the technical sessions, among them 49 students from the University of British Columbia, Montana School of Mines, University of Idaho, University of Washington, State College of Washington, and Gonzaga University. The organization committee had developed plans that put the cost of hotel and official luncheons and dinners within reach of a college student. A pleasant and unplanned affair was the student banquet on Thursday evening, attended by 81. The student dinners were paid for by four contributing companies: Harvey Aluminum, Bunker Hill & Sullivan, Colorado Fuel & Iron, and du Pont de Nemours.

The ladies' activities included golf at the Spokane Country Club and a luncheon which more than 80 attended. The Coeur d'Alene subsection gave a skit. Some of the ladies also attended the luncheons of the Metals Branch Thursday noon, and the Mining Branch Lunch Friday. A total of 151 attended the metals function, while 165 were at the mining affair. The banquet, attended by 233, was followed by dancing and entertainment.

Standing in the lobby of the hotel the casual observer could note cowboys, prospectors with their Geiger counters, and, of course, the conferees making decisions as to where to go next. The Kaiser Aluminum & Chemical Corp. provided buses for a visit to the reduction plant at Mead and the fabricating facilities at Trentwood. Some 120 men and women took advantage of this opportunity on Thursday afternoon.

K. W. Haagensen, director of public relations for Allis-Chalmers Mfg. Co., spoke on "We have what it takes—if we take what we have." He reviewed the present engineering man power situation in the light of needs and enrollment. He recommended that we think about and improve what we have and not worry about "isms" such as communism. He stressed axioms of human engineering and summed up the responsibility of engineers towards the companies and communities. "To understand people is the key to success, to sell is success."

At the Mining Branch Luncheon, William W. Mein, Jr., Vice President of the AIME, spoke on "Opportunities in Industrial Minerals." This, he said, was closely tied to population increase and a steadily rising standard of living. He stressed the need for a continuous program of basic research in industrial minerals.

At the banquet, Thomas W. Delzell, chairman of the board of Portland General Electric Co., said that power development in the Northwest is going to require an expenditure of 1 million dollars per day for the next ten years to meet the requirements of the region.

One of the highlights of past Pacific Northwest Conferences has been the Mineral Industries Education session. John P. Spielman, dean of Mineral Industries at Washington State College, chose a panel representing the elements of mineral engineering education, and the present trends in general education for engineering students. A recent graduate, J. B. Bramer, 1950 Montana School of Mines, discussed what he felt had been useful to him and what had not. Modern trends in curricula were illustrated by the one adopted at the University of California, and presented by Prof. S. F. Ravitz.

Extractive Metallurgy

Nine excellent papers covered a wide variety of subjects. Papers were presented at two sessions, with attendance at each approximately 100.

Three of the papers described processes in successful operation in the Northwest. These were 1) a description of the FluoSolids roasting plant at Anaconda's Yerington mine at Weed Heights, Nev., by Howard Jackey, foreman of the FluoSolids and Acid Plant; 2) a discussion of the slurry preparation plant for spraying reverberatory arches at the Tacoma smelter by C. R. Low, general superintendent; and 3) description of the operation of the plant of the Salt Lake Tungsten Co. by B. T. Burwell, superintendent.

Two papers given by A. J. Kauffman, Jr., and F. W. Wessel of the U. S. Bureau of Mines at Albany, Ore., discussed the work being done by that organization to develop specific mineral resources of the Northwest. Another paper by John H. Dismant of the State College of Washington gave a workable process for production of low carbon cobalt by electrothermic processes.

An outstanding paper discussing the effect of germanium in the electrolytic zinc cell, together with a description of a method for quantitative determination of very minute quantities of germanium by infrared spectroscopy, was presented by James H. Foreman, a graduate student at the State College of Washington.

S. C. VanPraag of the Albany Felt Co. brought the members up to date on the progress being made in use of new synthetic fibres in dry filtration. One of the most interesting talks was an informal one by E. R. Marble on his recent visit to Japanese smelters and refineries. —*R. J. Lapee*

Minerals Beneficiation

A working model of the gyratory ball mill invented by A. W. Fahrenwald attracted considerable attention from the 60 persons present. The gyratory ball mill differs from the conventional gravity mill with respect to the axis of the mill, which is vertical, and the fact that the mill does not rotate on its axis. The mechanism swings the mill in a circle, yet prevents the mill from rotating on its own axis. The new mill can be operated on a batch or continuous basis for wet or dry grinding and has capacities of four to

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Don't Forget . . . .

Black Hills

October 2 to 5—MGGD Fall Meeting and Black Hills Regional Meeting Ind. Min. Div., Rapid City, S. D.

Rocky Mountain

October 6 to 8—MBD Fall Meeting and Rocky Mountain Minerals Conference, Salt Lake City. (See Advance Program, ME, May 1955, page 489.)

Southeast

October 27 to 29—Ind. Min. Div. Fall Meeting, Charlotte, N. C.

seven times that of the conventional ball mill.—*J. W. Lowry*

Geology

Approximately 75 registrants attended the session. Two papers resulting from the investigations of the USGS in the Coeur d'Alene mining district over the past few years led off the session.

L. W. Hobbs described the pattern of ore deposit distribution in the Coeur d'Alene, and Verne C. Fryklund gave the results of a geochemical study of Star mine sphalerite.

One of the few papers ever presented on the geology of the Metaline Falls area, given by John J. Fritts on the Pend Oreille mine, told of the puzzling geological features of that district.

Another paper resulting from USGS work described a dumortierite deposit north of Basin, Mont. Paul E. Meyer gave this as part of the study of the Boulder Batholith.

W. T. Irvine, senior geologist for the Consolidated Mining & Smelting Co. of Canada, gave an interesting paper on the Tulsequah area of British Columbia.—*R. E. Sorenson*

Mining

The mining session was attended by 125. The first paper by Albert Beck and W. A. Boyer described electronic signaling devices used in shafts in the Asarco mines of the Coeur d'Alene mining district, with special emphasis on inclined shafts.

Wallace E. Crandall told the story of the longest recent tunnel project in the Coeur d'Alene in his paper "The Star 2000 Surface Line Crosscut." This project connects the top of the shaft to the Star mine of the Sullivan Mining Co. to the surface facilities and includes an underground crushing installation.

The use of self-loading transport, the "Gismo," as a support for rock drills at the Grandview mine was described by John W. Currie of the American Zinc-Lead & Smelting Co. The use of this machine has resulted in a large increase in tonnage of ore produced per manshift.

A substantial saving in materials cost, in addition to other benefits, has resulted from the use of pipe chutes in sand-fill stoping practice at Dayrock, according to Rollin Farmin and Carville Sparks of the Day Mines Inc. Lightweight steel rolled into short-length tubes of 30-in. diam are used for chutes instead of timber.

W. A. Boyer in his paper on the safety factor of mine hoist ropes proposed a new method for determining the correct size and loading of such ropes. A method of determining when a mine hoist rope should be discarded was also offered. —*J. C. Kieffer*

Industrial Minerals

The Industrial Minerals Session, consisting of five papers concerning source, processing or distribution of certain nonmetallic products in the Pacific Northwest, was attended by approximately 60, many of whom were students. The papers varied in scope from a general résumé of industrial minerals in the Pacific Northwest to one on the limited specialty of the technology and application of pyro processes in nonmetallic industries.—*P. E. Oscarson*

President Smith Attends Two-Day Nevada Section Meeting At Ely

W. W. Mein, Jr., AIME Vice President, was the featured speaker and representative of President H. DeWitt Smith at a dinner highlighting a very successful meeting of the **Nevada Section** in Ely, Nev., March 25 and 26.

Beginning with registration Friday afternoon at the Hotel Nevada, the meeting continued with technical sessions and field trips on Saturday, concluding with a dinner Saturday evening at the Elks Home. A total of 155 men registered and total attendance, including the ladies, was over 200. Following the registration, Consolidated Coppermines Corp. was host at a cocktail hour and buffet supper Friday evening at the Hotel Nevada.

Saturday morning technical sessions were held at the Elks Home, starting at 9:30 am, with a short recess at 11 am. John N. Butler, Secretary of the **Nevada Section,** presided during the first session, at which Merritt K. Ruddock, vice-president of Cal-Uranium Co., Moab, Utah, spoke on "Uranium Prospecting and Production in the West." Of particular interest to the Nevada people present were his concluding remarks that chances for finding high grade orebodies in the Plateau area are decreasing and much future production may lie in large, low grade deposits which may be discovered in areas like Nevada.

Russell Ball, briefing officer of the Atomic Energy Commission at Las Vegas, spoke on "Atomic Bomb Testing in Nevada." He emphasized the great value of the easily accessible Nevada test site to the atomic program. He also especially emphasized the firm belief of the AEC that there is no real danger to the public from atomic fall-out, and gave test figures to show the lack of danger.

Following these talks, the first public showing of a film sponsored by Westinghouse and starring Fred MacMurray on peacetime uses of atomic energy was presented by H. B. Hodgins, Salt Lake City manager for Westinghouse.

The second session was opened at 11 am by Louis D. Gordon, executive secretary of the Nevada Mining Assn. Walter L. Smith, geologist for Shell Oil Co. in eastern Nevada, spoke on "Oil in Nevada." He traced the history of the search for oil in the state since 1870.

The concluding talk was given by John C. Kinnear, Jr., general manager, Nevada Mines Div., Kennecott Copper Corp., who spoke on "Kennecott and Coppermines Operations in the Ely Area." Mr. Kinnear showed a district map of the Ely copper area and gave many details on operations. He particularly emphasized the cordial relations enjoyed in joint operations on Kennecott and Coppermines ground.

Saturday afternoon the group divided into three field trip parties, one to the Shell oil well in Railroad Valley, one to the Kennecott mill and smelter at McGill, and one to the mining operations.

The meeting concluded on Saturday evening with a cocktail hour sponsored by Kennecott Copper Corp., and a dinner at the Elks Home, attended by about 180 persons. W. W. Mein, Jr., spoke briefly on AIME activities and plans for the future.

Around the Sections

• The **Eastern North Carolina Subsection** held a dinner-meeting at Chapel Hill recently. Prof. G. R. MacCarthy gave an illustrated talk on his work in the coastal plain of northernmost Alaska. Ladies of the section have decided to form an auxiliary and are making plans for the future.

• W. F. Dietrich, chief, Branch of Ceramic and Fertilizer Materials, U. S. Bureau of Mines, spoke on "Highlights of Recent Developments in Synthetic Minerals," at the May meeting of the **Washington, D. C., Section.** He discussed some of the more significant aspects of mineral synthesis, with particular reference to progress in the synthesis of mica and electronic-grade quartz crystal.

• Students at the University of Alaska often travel a far piece to matriculate. Three applications for student membership bear this out: Stewart P. Butler comes from Valley Stream, N. Y., Kenneth W. Carson calls Kennewick, Wash., home, and George F. Hawkins hails from Baltimore, Md.

• The **Montana Section** held a joint meeting with the **Anderson-Carlisle Society,** student chapter of the AIME at Montana School of Mines. Aim of the meeting was to acquaint members of the Montana Section, guests, faculty, and students with developments and research programs at Montana School of Mines. Papers presented were: "New Developments in Ore Research," by Paul Allsman, graduate student; "Flotation Research Using the Environment-Controlled Free-Bubble Contact-Angle Apparatus," by Darrell E. Bodie, graduate student; "A New Idea for Mucking," by Don Rohrenbach, senior student; "The Quantitative Determination of Tungsten by X-ray Fluorescence Spectrometry," by Ford Knight, graduate student; "Rotary Drilling with Gas," by Ernest B. Stenmark, junior student.

• A group from **Colorado Plateau Section** took a field trip through Eagle mine, mill, and plant recently, at Gilman, Colo., courtesy of the Empire Zinc Div., New Jersey Zinc Co. The section has scheduled its spring meeting for the Grand Imperial Hotel, Silverton, June 18. A technical session in the afternoon will be followed by a dinner-dance in the evening.

• The **Florida Section** has been host to several interesting speakers in the last few months. Among them were Ralph E. Kirk, AIME Director, who spoke on current affairs of the Institute; James Koenig, director of the Atomic Energy Commission's

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Albert M. Austin, patent attorney, receives his Legion of Honor pin and scroll from AIME President H. DeWitt Smith in the top photo. Cornelius F. Kelley, retired chairman of the board of Anaconda, addresses the New York Section after receiving his Legion of Honor pin in the center picture. In the bottom photo C. Y. Wang, director of research Wah Chang Corp., receives congratulations from Mr. Smith.

Florida District office, who discussed the probable future need and use of fissionable materials; and W. L. Hill of the U. S. Dept. of Agriculture, who reviewed the relationship of the mineral industry and the fertilizer needs of agriculture. The section also held a symposium on surface use of mining lands.

• The May meeting of the **New York Section** was highlighted by a talk from J. Roy Gordon, vice president of International Nickel Co., whose remarks preceded the showing of a 33-mm color film *Mining for Nickel*. The film depicted Frood-Stobie operations, shaft sinking at Lavack, and underground stoping at the Creighton mine.

• The **St. Louis Section** visited the Granite City Steel Co. plant at Granite City, Ill., starting with the coke oven & blast furnace dept. After dining in the company cafeteria, the group visited open hearths, blooming mill, hot strip mill, cold sheet mill, and tin mill. The tour indicated some of the results of the firm's modernization program and was of special interest to the many students from St. Louis University, Washington University, and the Missouri School of Mines who attended.

• Historic scenes from Atomic Energy Commission plants in Idaho and Pittsburgh, now unclassified, are the subject of *A Dawn's Early Light*, a 30-min sound movie produced by Westinghouse Electric Co. Starring Fred MacMurray and featuring Fay Wray and Jack Dimond, the film is in color and black and white. The film is available on loan without charge or can be purchased outright. Contact Westinghouse Film Div., Westinghouse Electric Corp., Box 2278, Pittsburgh.

A new all-Institute directory was announced in the March issue. Members may obtain copies of the directory without cost by using the coupon that appeared on page 301, Mining Engineering, March 1955, or by letter. Please use the coupon if possible.

CIM Attracts Record Crowd

The annual meeting of the Canadian Institute of Mining and Metallurgy in Toronto, April 18 to 20, had a registration totaling about 1400 men and 500 women, out of a total CIM membership slightly exceeding 5000.

Eighteen sessions occupied the three days of the meeting, with 55 papers on technical subjects. Of special interest was an exposition of International Nickel Co.'s newly developed flash smelting process for copper concentrate, using oxygen gas for combustion. [A report of this process is given on page 534 of this issue.] Equally interesting was a series of papers on the Lynn Lake property of Sherritt-Gordon in northern Manitoba, where a nickel-copper-cobalt ore is being mined and treated by an entirely different process from that used by Inco, devised by Frank Forward, of the University of British Columbia.

At the welcoming luncheon, AIME President H. DeWitt Smith was the guest speaker. A *hands-across-the-border* spirit was evident in many ways. The retiring Secretary of the AIME, Edward H. Robie, was tendered a special tribute at the annual dinner by CIM president Charley Huston, who noted that he had worked in Canada, had long been a member of the CIM and attended many of its meetings, and had done much in promoting joint meetings and cooperation between the societies.

A. L. Penhale of Thetford Mines, Quebec, was inducted into office as president for the coming year.

Drilling Symposium At U of Minnesota

The School of Mines and Metallurgy and the Center for Continuation Study at the University of Minnesota is planning its Annual Drilling Symposium for October 13 to 15.

Special arrangements will bring European and U. S. authorities to the campus to discuss the following subjects: rotary drilling of small diameter holes, with particular reference to hard rock; application of tungsten carbide to bits for small hole drilling, emphasizing preparation, manufacture, metallographic structure, and physical properties; and rotary-percussive drilling as a new method for use in the U. S.

New Building Decision Deferred

At the meeting of the AIME Board of Directors on April 13, discussion continued on the location of the proposed new building to house the national engineering societies. L. F. Reinartz presented an amplified report of the Committee of the Five Presidents, stating in more detail than had been done heretofore the reasons that had impelled the Committee to recommend a move to Pittsburgh. He said that the Committee had again met on April 4, and four of the five members had reiterated their preference for Pittsburgh, based on all the information then at hand. The president of the Civils had given a minority report recommending that decision be deferred.

In any case, it is expected that the Annual Meetings of the AIME in even-numbered years would continue to be held in New York, also that a small branch office of each of the societies in New York would be advisable.

It was felt that interests anxious to have the societies remain in New York had become much more active and that their story should be heard before a final decision is made; still, the decision should not be unduly postponed.

Following the extended discussion, the Board voted to defer action until the next Board meeting, on June 15. In the meantime the AIME representatives on United Engineering Trustees, holding group for the present building, are asked to study any new factors that may arise.

Among those who welcomed H. DeWitt Smith and Carl E. Reistle, Jr., President-Elect 1956, to Arizona (during a recent tour of the Western Sections) were Lawrence Ormsby, left, mine superintendent, and Lyle M. Barker, right, manager of the Morenci mine. The wrong engraving appeared above this caption on page 490, MINING ENGINEERING, May issue.

PERSONALS

DANIEL C. JACKLING

Daniel C. Jackling has been promoted to brigadier general in the Utah National Guard and awarded the Utah National Guard service ribbon with four silver beehive devices and one bronze beehive device "representing 46 years of distinguished, patriotic service." Mr. Jackling has been an honorary member of the AIME since 1941. He received the AIME William Lawrence Saunders Medal in 1930 and the John Fritz Medal in 1933. Mr. Jackling was President, AIME in 1938.

Kenneth A. De Longe is in charge of the iron & nonferrous castings section, Development & Research Div., International Nickel Co. Inc., New York. Mr. De Longe joined Inco in 1937 as a member of the cast iron section of the company's research laboratory, Bayonne, N. J., and in 1940 was transferred to the Development & Research Div. in New York as a specialist on Ni-Hard.

Helgi Johnson, director of the Bureau of Mineral Research and chairman of the geology dept., Rutgers University, New Brunswick, N. J., has been named executive director of the Yellowstone-Bighorn Research Assn. at Red Lodge, Montana.

Howard G. Grim, general manager of operations, Heppenstall Co., Pittsburgh, has been elected vice president in charge of manufacturing. **Hugo Neu,** president Hugo Neu Corp., New York, was elected to the board.

C. L. Kingsbury, Jr., Reserve Mining Co., Babbitt, Minn., is superintendent, crushing and concentrating operations at the Babbitt plant. Mr. Kingsbury joined Reserve in 1951 as a field engineer. In 1952 he was advanced to general foreman of concentrating and crushing operations.

Herbert Buchholtz, formerly mining engineer, Anaconda Copper Co., Darwin, Calif., is assistant to superintendent, mining, Riverside Cement Co., Riverside, Calif.

Elmer L. Wiley has been made head of a new division-wide safety organization at Chino Mines Div., Kennecott Copper Corp., Hurley, N. M. Safety engineers at the company's mine in Santa Rita and the mill and smelter in Hurley will work with Mr. Wiley as will the fire departments of both plants. Safety engineer at Santa Rita is **W. H. Snell. D. M. Berry** is the Hurley safety engineer and **F. E. Boren** is fire marshall for the division. Working with Mr. Wiley in an advisory capacity is **S. M. Jarrett,** chief safety engineer of Kennecott's Braden Copper Co. in Chile. A veteran safety man who first began safety work in the coal mines at Gallup in 1928, Mr. Jarrett has been instrumental in setting an unusual record at the Chilean mining operations. Braden has received the Inter-American Safety Council award for the lowest accident frequency rate in mines throughout Latin-America for the past eight years. Mr. Wiley was formerly safety director, West Virginia Coal & Coke Co., Omar, W. Va.

G. H. Craig is general manager, Crane Hoist Engineering Corp. of Texas, Houston. This is a new corporation formed in association with Crane Hoist Engineering Corp. of California at Los Angeles and Oakland. Mr. Craig was with Manning, Maxwell & Moore Inc., San Francisco, and joined this firm in 1944. He was made district manager in 1946.

William P. Jones, general manager, Chemical Construction (Inter-American) Ltd., Toronto, has been transferred to Chemical Construction Corp., New York. He is metals dept. manager.

Henry D. Clark, Jr., formerly mine superintendent, United Verde Branch of Phelps Dodge Corp., is assistant mine superintendent, Copper Queen Branch, Bisbee, Ariz.

William A. Seedorff has been promoted to project engineer, International Minerals & Chemical Corp., Carlsbad, N. M. He will be responsible for management of all contract work done for the Carlsbad plant of the Potash Div. and for other engineering planning assignments. He will report directly to **A. B. Chafetz,** assistant superintendent of maintenance and engineering.

Jack W. Reinhart was named on March 1, manager of geology and quarry operations dept., Perlite & Dicalite Divisions, Great Lakes Carbon Corp., Walteria, Calif. Mr. Reinhart joined the company in March 1953 as a field geologist and was made chief geologist in November 1953. Prior to this he was with American Smelting & Refining Co. Mr. Reinhart has also been named to the mining committee of the Los Angeles Chamber of Commerce.

Byron E. Grant has been named assistant general manager, Braden Copper Co., Chilean Div., Kennecott Copper Corp. This company maintains operations in the Sewell-Rancagua area. Mr. Grant, before he resigned in 1954 to enter private practice in Salt Lake City as a mining consultant, was director of labor relations, U. S. Smelting Refining & Mining Co. He was first employed by this company in 1936 as a geologist in the Bingham, Utah, mining area.

R. G. Waters, who retired after more than 48 years with Glen Alden Coal Co., Wilkes-Barre, Pa. is now available for consultation in anthracite mining and several branches of civil engineering. Mr. Waters' address is 720 Hickory St., Scranton, Pa.

Merwin Bernstein has left Cerro de Pasco Corp. after three years as geologist at Cerro de Pasco mine. He has joined the exploration dept. Kennecott Copper Corp., Lima, Peru.

Chancellor Henry T. Heald of New York University (right) confers the honorary degree of Doctor of Engineering upon Augustus B. Kinzel, vice president, research, Union Carbide & Carbon Corp., New York, and Vice President, AIME. At left is LeRoy E. Kimball, vice chancellor of the University. The honor was bestowed May 7 at the final convocation marking the 100th anniversary of the NYU College of Engineering. Thirteen outstanding engineering, scientific, industrial, and civil leaders received degrees.

Ralph H. Wilpolt has been appointed deputy director, Exploration Div., of the Grand Junction operations office of the Atomic Energy Commission, Grand Junction, Colo. A graduate from Lawrence College, Appleton, Wis., and of Northwestern University, Mr. Wilpolt has been in geology and mining nearly two decades with both private industry and Government. For five years he was with the U. S. Geological Survey in Virginia, Tennessee, West Virginia, Kentucky, Arkansas, and New Mexico, his last position being supervising geologist in the Lexington, Ky., office. Mr. Wilpolt has worked for American Smelting & Refining Co. in Mexico, Clinchfield Coal Corp., and Sierra Ancha Mining Co. He was also at various times chief, Geologic Branch, AEC Exploration Div., Grand Junction, and an associate professor of geology at New Mexico School of Mines.

E. H. Hebden, district manager, Jeffrey Mfg. Co., Beckley, W. Va., since 1947, is manager of the company's mining renewal parts sales in Columbus, Ohio. Mr. Hebden is succeeded by **John L. Phillips, Jr.,** assistant manager of mining apparatus sales in the Jeffrey home office.

Joseph Zuraw is superintendent, Penokee iron mine, Ironwood, Mich. Mr. Zuraw has been acting superintendent of the mine ever since North Range Mining Co. took over operations last fall.

Ralph E. Magnuson, Jr., administrative assistant to **Hugh J. Leach,** manager of Minnesota mines, Cleveland-Cliffs Iron Co., Hibbing, Minn., has been transferred to Ishpeming, Mich., as administrative assistant to **S. W. Sundeen,** manager of ore development for Cleveland-Cliffs. This announcement was made by **Grover J. Holt,** general manager. Mr. Magnuson was given a farewell party by 60 CCI staff members.

C. H. Sleeman, Minnesota Ore Div., Jones & Laughlin Steel Corp., Virginia, Minn., is now assistant manager. Mr. Sleeman joined J&L as a mining engineer in 1946. He was appointed general mining engineer in 1952 and assistant to the manager in 1953. **Charles H. Grant** is chief mining engineer of the Minnesota Ore Div. Mr. Grant has been with the company since 1950. Among others promoted at J&L are **William Ball,** now superintendent, Hill Annex mine, Calumet, Minn., **Julius Strande,** superintendent, Longyear mine, Hibbing, Minn., and **Dan Madich,** general maintenance foreman for the Division.

James A. Barr is in Jordan on a mission for the World Bank. On his way back Mr. Barr will attend conferences in Rome, Paris, and London.

Dorsey Hager and **Charles Gill Morgan** are consulting geologists for Chesapeake & Colorado Uranium Corp., Washington, D. C.

CURTIS L. WILLMOTT

Curtis L. Willmott, vice president, McDowell Co. Inc., Cleveland, has been elected to the board of the Wellman Engineering Co., Cleveland. Mr. Willmott will direct the combined and coordinated sales program for all the McDowell enterprises, which include Wellman Engineering Co., Cleveland, Williams Bucket, Akron, Locomotive Crane, Cleveland, Dwight-Lloyd, Cleveland, and the Anker-Holth Div., Port Huron, Mich. **John J. McGlone** is sales manager of Wellman's Williams Bucket Div. He was an inspector with the Bridge Operators' and Inspectors' Assn.

Charles R. Skinker has been appointed secretary of Haile Mines Inc., and its subsidiary companies, Tungsten Mining Corp. and Manganese Inc., it was announced by **H. S. West,** president. Mr. Skinker, who has been associated with The New Jersey Zinc Co. in various capacities for the past ten years, assumed his new duties Apr. 1, 1955.

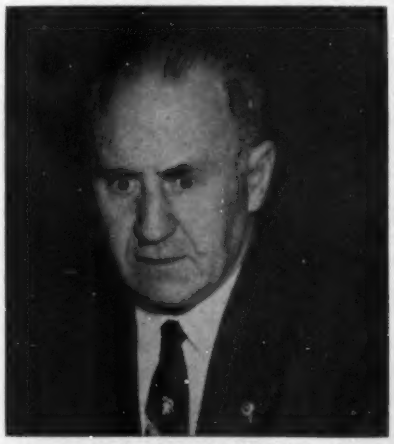
Lars E. Ekholm has been appointed manager of the Sales Div., Climax Molybdenum Co. Mr. Ekholm, who received his degree as a metallurgical engineer from Lehigh University in 1929, has been associated with this company since 1946. Before joining Climax Molybdenum, Mr. Ekholm spent 15 years with Alan Wood Steel Co. where he served in the technical dept. as chief metallurgist and in the sales dept. in various sales and executive capacities.

Alex Stewart, director of research for National Lead Co., New York, has been awarded a gold watch in recognition of 25 years of service. Mr. Stewart joined the company in 1930 and took over his present position in 1947. He also directs the company's atomic energy activities, and is vice president and general manager of National Lead Co. of Ohio, a subsidiary which operates the Atomic Energy Commission plant in Fernald, Ohio, and National Lead Co. Inc., which operates the Winchester, Mass., laboratories for the AEC.

Andrew Fletcher, president, St. Joseph Lead Co., New York, and Past President of AIME, was elected president of the Lead Industries Assn. at the 27th annual meeting in Chicago. He succeeds **J. B. Haffner,** president, Bunker Hill & Sullivan Mining & Concentrating Co., Kellogg, Idaho. **K. C. Brownell,** president, American Smelting & Refining Co., N. Y., **J. A. Martino,** president, National Lead Co., N. Y., and **M. M. Zoller,** vice president, Eagle-Picher Co., Cincinnati, were elected as vice presidents and **Robert L. Ziegfeld,** was re-elected secretary-treasurer. Among those elected as directors were: **W. H. H. Cranmer,** president, New Park Mines Co., **H. L. Day,** president, Day Mines Inc., **S. A. Easton,** chairman of the board, Bunker Hill & Sullivan Mining & Concentrating Co., **Clarence Glass,** vice president, Anaconda Sales Co., agents for International Smelting & Refining Co., **F. S. Mulock,** president, U. S. Smelting Refining & Mining Co., **J. P. Ruth,** vice president, Glidden Co., and **Jean Vuillequez,** vice president, American Metal Co. Ltd.

C. Hyde Lewis, a veteran of 33 years in the mining industry, has been elected president of the New Idria Mining & Chemical Co., Idria, Calif. Mr. Lewis was a naval officer in World War I. After graduating at the University of California, he started with Phelps Dodge Corp., in 1922, and joined New Idria in 1936.

Marshall S. Walker, former president, Walker & White Inc., New York, has retired. Mr. Walker was Presidential Appointee to the Annual Assay Commission in 1930 and 1938. After World War II he was consultant, representative, and umpire for Government and other purchasers of tungsten ores.



HAROLD E. ROWEN

Harold E. Rowen is general manager of the new Dwight-Lloyd Div. of McDowell Co. Inc., Cleveland. He was vice president of Sintering Machinery Corp., Netcong, N. J., recently acquired by McDowell Co. Inc. Mr. Rowen served in the U. S. Navy in World War I.

Louis Koenig is now vice president of Southwest Research Institute, San Antonio, Texas, and will direct the expanded chemistry, chemical engineering, minerals, metals, high energy, and applied biology divisions. Mr. Koenig received his Ph. D. from New York University and has been with Southwest Research Institute since 1951. He was assistant director of research at Stanford Research Institute and chairman of Armour Research Foundation's chemistry and chemical engineering dept. Mr. Koenig is advisor to the Secretary of the Interior on the Saline Water Program.

H. I. Altshuler, consulting mining engineer, St. John d'el Rey Mining Co. Ltd. and the New York & Honduras Rosario Mining Co., has been elected vice president and director of the latter company.

Ralph D. Parker has been elected vice president, International Nickel Co. of Canada Ltd. Mr. Parker, who joined Inco in 1928, is president of Canadian Nickel Co. Ltd., the exploration and prospecting subsidiary of Inco, and retains his position as general manager of Canadian operations.

Fred S. Haley, for the past ten years field engineer with U. S. Smelting Refining & Mining Co., is mine manager for Wyoming Uranium Corp., Lander, Wyo.

ROBERT H. RAMSEY

Robert H. Ramsey, former editor of *Engineering & Mining Journal,* is secretary of St. Joseph Lead Co., New York. **Alvin W. Knoerr** who was managing editor of *E&MJ* is editor. **George P. Lutjen,** associate editor, is now managing editor.

Herbert E. Hawkes of the geology and geophysics dept., MIT, has returned from Trondheim, Norway, after giving a series of lectures on geochemical methods of mineral exploration at the Norwegian Technical University.

Drew M. Thorpe, has been appointed executive vice president of General Refractories Co., Philadelphia.

DIONYS BURGER

Dionys Burger has resigned from the Tasmanian Geological Survey and is geologist to the Australasian Oil Exploration Ltd., Uranium Div., South Australia.

Kenneth M. Dewar has resigned as superintendent of the Errington iron mine, Steep Rock Iron Mines Ltd., Steep Rock Lake, Ont., and has joined the mine plant construction firm, R. M. Way & Co., Toronto.

George H. Kemmer, who has been carrying out heavy mineral investigation work in the U. S. since returning from Ethiopia, is doing exploration work in shield areas of Venezuela. His address is Apartado 2021, Caracas, Venezuela.

A. Clifford Melting has been appointed vice president of Western Mines Inc., subsidiary of Western Development Co. of Sante Fe. He was concentration plant superintendent for Lone Star Steel Co. During World War II Mr. Melting was a technical advisor to the mining div., War Production Board, Salt Lake City.

Julian Feiss, Kennecott Copper Corp., New York, succeeds **George Corless** as AIME representative on Engineering Manpower Commission. His appointment was made to the end of 1955 for the balance of Mr. Corless' term.

Claude E. Schmidt is chief metallurgist, Homestake Mining Co., Lead, S. D.

Eugene Pfleider, head, mineral engineering dept., University of Minnesota, will spend six weeks this summer visiting schools of mines in Sweden, Germany, France, and England. He will also visit iron ore producing areas and principal mining districts in Sweden. Mr. Pfleider will discuss mining engineering education and research with the top professors and operators in Europe in order to set up a better exchange of ideas between the two continents in these fields. He will take part in the Centenary Congress of the Société de l'Industrie Minérale and the International Exhibition of the Mining Industry in Paris, June 18 to July 3.

Sherwin F. Kelly is on a trip through the Caribbean and Central America in connection with the operations of his geophysical firm in the fields of mining and water exploration. He expects to return to Wilmington, Dela., early in June.

J. M. Rose who was with International Nickel Co., Sudbury, Ont., has joined the engineering staff of Howe Sound Exploration Co. Ltd., Snow Lake, Man.

Odin A. Sundness, vice president of Snyder Mining Co., Minn., has retired. Mr. Sundness joined the Shenango Furnace Co., forerunner of the Snyder Mining Co., in 1911 as an engineer at the Whiteside underground iron mine Buhl, Minn., Mesabi range. Prior to that he worked with Oliver Iron Mining Co. during his years at the University of Minnesota. Mr. Sundness has been a key figure in Lake Superior region mining and industrial affairs for many years. He was one of the originators of the Engineers' Club at Northern Minnesota and was active in organizing a Minnesota Section of the AIME. His personal hobby is peat, and last July he was appointed to represent the State of Minnesota at the International Peat Symposium in Dublin, Ireland.

Howard Barkell, vice president, Phelps Dodge Refining Corp., New York, has been elected to the board of directors.

EUGENE D. GARDNER

Eugene D. Gardner, chief mining engineer of the U. S. Bureau of Mines, has retired after nearly 44 years of government service. Mr. Gardner was born at West Jordan, Utah, in 1885 and was graduated from the University of Utah. His Government service began in 1911 when he took a job as mineral examiner for the U. S. Forest Service. Mr. Gardner transferred to the USBM in 1918 and his duties have taken him all over the U. S., Alaska, and many foreign countries. During World War II he was responsible for exploration, metallurgical research, and the construction and operation of pilot plants. He holds the Distinguished Service Award and Gold Medal of the U. S. Dept. of the Interior, and in February this year he received the AIME Jackling Award. Although he has retired, Mr. Gardner will continue to be available to the USBM on a part-time consulting basis, for work on special projects.

Albert Hopkins, managing director of Hopkins Exploration Consultants, Toronto, is going to London to open another branch office there. He will also attend the Centenary Congress of the Société de l'Industrie Minérale in Paris.

William J. Harris of Battelle Memorial Institute, Columbus, Ohio, has been named assistant to the director with headquarters in Washington, D. C. He will represent Battelle in its relationship with numerous governmental organizations sponsoring research in Battelle laboratories. In 1950 Mr. Harris was the co-recipient of the Mathewson Medal presented by the Institute of Metals Div. of the AIME. He has also been chairman of the National Membership Committee and the National Student Prize Paper Award.

Francis O. Case, president, Glen Alden Coal Co., Wilkes-Barre, Pa., has been elected to the board of the Miners National Bank. Prior to joining Glen Alden in 1953, Mr. Case was vice president of Anaconda Copper Mining Co. and president of Anaconda Aluminum Co.

Richard M. Foose, chairman, geology dept., Franklin and Marshall College, Lancaster, Pa., has been awarded a Faculty Fellowship by the Fund for Advancement of Education of the Ford Foundation for the year 1955 to 1956. Mr. Foose plans to study the evolution and development of thought in the fields of structural and economic geology beginning with the 18th century.

R. C. Meaders is vice president of Aerofall Mills Inc., Columbus, Ohio, a new subsidiary of Aerofall Mills Ltd. of Canada. For the past four years Mr. Meaders was U. S. manager, Aerofalls, Niagara Falls, N. Y.

Paul Schapiro is mine engineer with the Banner Mining Co., Tucson, Ariz. He was shift foreman at the Wah Chang Mining Corp., Bishop, Calif.

R. Worth Vaughan has been elected as executive vice president and **Oscar S. Straus** as vice president and treasurer, American Smelting & Refining Co., New York. Mr. Vaughan joined the company in 1937 as assistant general counsel and became vice president and general counsel in 1947 and a director in 1948. He will continue as general counsel. Mr. Straus came to the company in 1946 as assistant to the treasurer and was made treasurer in 1949. He became a director in 1951.

Clark L. Wilson is chairman and **W. F. Rappold** is vice chairman of the Natural Resources Committee of Utah Assn. of Chambers of Commerce.

J. C. McFarlane is mining engineer, Rare Metals Corp. of America, Cameron, Ariz. He was previously at Yellow Pine Mine, Stibnite, Idaho.

F. S. Mulock, president of U. S. Smelting Refining & Mining Co., Boston, Mass., has been elected president and a director of the American Zinc Institute, New York. **C. Merrill Chapin, Jr.,** St. Joseph Lead Co., New York, is a vice president and a director. **R. G. Kenly,** The New Jersey Zinc Sales Co., New York, and **E. H. Snyder,** Combined Metals Reduction Co., Salt Lake City, are also vice presidents. **Erle V. Daveler,** American Zinc, Lead & Smelting Co., New York, has been re-elected treasurer and **John L. Kimberley** is secretary. **Ernest V. Gent** continues as executive vice president. The following were also elected directors for the term ending 1958: **H. D. Carus,** Matthiessen & Hegeler Zinc Co., La Salle, Ill., **M. L. Havey,** The New Jersey Zinc Co., New York, **S. H. Levison,** American Smelting & Refining Co., New York, **R. F. Orr,** Athletic Mining & Smelting Co., Fort Smith, Ark., **O. A. Rockwell,** Eagle-Picher Co., Mining & Smelting Div., Miami, Okla., **C. H. Winship, Jr.,** Phelps Dodge Corp., New York, and **H. L. Young,** American Zinc Sales Co., St. Louis.

OBITUARIES

An Appreciation of
Harvey S. Mudd
By James L. Bruce

Harvey Seeley Mudd passed away unexpectedly and suddenly as a result of heart failure in the early morning of Apr. 12, 1955, at his home, 1240 Benedict Canyon Drive, Beverly Hills, Calif. He was born in Leadville, Colo., on Aug. 30, 1888, son of Col. Seeley W. Mudd, and Della Muloch Mudd. Col. Mudd was a renowned and highly respected mining engineer whose elevated sense of ethics and professional responsibility and whose influence is strongly reflected in Harvey's life. In 1902, he moved to Los Angeles with his father and family.

As a student, Harvey attended Los Angeles High School, Stanford University 1906 to 1908, transferring to graduate as engineer of mines at Columbia in 1912. The following year he married Mildred Hardy Esterbrook. This marriage brought a daughter, Caryll—now wife of Dr. Norman F. Sprague—and a son, Henry Thomas Mudd, who succeeded Harvey as president of Cyprus Mines Corp. when Harvey became chairman of the board on Jan. 1, 1955.

After graduation from Columbia, Harvey was employed for two years as mining engineer at Shattuck Denn mine at Bisbee, Ariz., then joined his father and Philip Wiseman at their Los Angeles headquarters from which he assisted in many mine examinations and mining operations.

Harvey Mudd was gifted with great talents, logical mentality and very unusual capacity for useful and persistent work. He loved people and was deeply interested in contributing to their educational and cultural development. As his experience grew he became still better qualified to extend the usefulness of his services; consequently he was surrounded by loyal, loving associates and friends, who now suffer great loss and sorrow from his passing.

In mining, Harvey's great adventure and romance was with the Cyprus Mines enterprise, resurrected from many centuries of oblivion by Charles Godfrey Gunther in an exploration program initiated by Col. Seeley W. Mudd and Philip Wiseman. Cyprus orebodies, worked for copper by the Phoenicians and Romans, idle for 1700 years, and obliterated by centuries of erosion, were rediscovered by Gunther in 1914, but only after courageous disregard of disappointing initial results. After discovery the ore development was interrupted by World War I. Harvey's close personal attention and leadership, commencing with his first visit to Cyprus in 1919, was responsible for carrying this enterprise

H. S. MUDD

through many trying years, with difficult operating and marketing conditions, to eventual prosperity. As president and managing director, he is to be credited with the excellent relations maintained with Cyprus Government representatives, with employees, and with market outlets skillfully developed under his close personal direction. He was responsible for greatly improved sanitary and living conditions of employees and related communities, and for many of the engineering features of construction and operation.

The Cyprus operation is the most important mining activity in the Near East, and one of Europe's greatest. The property embraces three large mines and several smaller ones. It is equipped with industrial railway, copper leaching and concentrating plant, power plant, jetty, tugs, and lighters, in addition to the mining plants. The corporation's residential property is extensive, and this is supplemented by excellent hospital, school, and community services. Several millions of tons of products have been shipped—by seaborne vessels—including cupreous pyrite, iron pyrite, copper concentrates, copper precipitates, and gold and silver. For some years a cyanide plant was in operation treating the gold-silver ore. The enterprise has been a major factor in the improvement of the economy and living standards of the Island of Cyprus.

As time passed, Cyprus Mines Corp.—through its subsidiary, Coronado Copper & Zinc Co.—acquired several mining properties in the western part of the United States. Coronado's Afterthought mine in Shasta County, Calif., and its group of mines at Johnson Camp in Cochise County, Ariz., have contributed substantial amounts of silver, lead, zinc, and copper to production. Recent acquisitions are the Old Dick and Copper Queen Mines near Bagdad, Ariz.

Under Harvey Mudd's energetic leadership as president of Cyprus Mines Corp., operations were extended into iron ore production when the corporation in 1953 joined with Utah Construction Co. for the successful development of Marcona Mining Co.—and associated ocean transport enterprises—organized to produce iron ore from a deposit situated about 300 miles south of Lima, Peru. In recent years the corporate activities have also branched into petroleum and natural gas development and production, partially through a subsidiary, Cyprus Petroleum Co., with indications that this will become quite successful. Harvey's good judgment and leadership are to be credited with much of this accomplishment.

During the growing years of Cyprus Mines Corp. the venturesome spirit, boundless energy, and friendly associations of Harvey Mudd led him into participation as an individual in other mining enterprises in which he often was the directing force, always very active in both administration and engineering. These ventures produced gold and silver at Cactus mine, Kern County, Calif.; silver at Silver Peak, Nev.; quicksilver at New Idria and Cachuma mines in California; silver, lead, zinc at Cia. Minera Venturosa near Namiquipa, Mexico. He was a director of Mesabi Iron Co.

In engineering and industrial fields detached from metal mining, Harvey Mudd's organizational skill and counsel was obtained through his service as director on the boards of directors of Southern Pacific Co., Founders Insurance Co., and others. He was a voting trustee of Pacific Mutual Life Insurance Co. He was an active director on the board of Texas Gulf Sulphur since 1926. He directed the development and operation of Pacific Alkali Co., which had been organized about 1925 by Colonel Mudd, Philip Wiseman, Harvey S. Mudd, Seeley G. Mudd and William L. Honnold to produce soda ash, sodium sesquicarbonate, and borax from the saline waters of Owen's Lake. The first commercial production of borax from Owen's Lake was from this enterprise, which was sold to Pittsburgh Plate Glass Co. in 1944. At the time of Harvey's death preparations were under way to produce borates by underground mining from property at Boron, Calif. The property contains part of one of the world's greatest borate deposits.

During World War I, Harvey Mudd served as assistant secretary of the War Minerals Committee, and in the Bureau of Mines in Washington as a technologist. He was a member of the Board of Consulting Engineers of the Los Angeles Metropolitan Water District which brought water to Los Angeles from the Colorado River. He was president of the Los Angeles Area War Chest in 1943, during World War II, consolidating the needs for local, national, and international purposes into one fund-raising campaign. In 1944 he

was appointed by Governor Earl Warren as head of the Citizens Advisory Committee of the State Reconstruction and Reemployment Commission. He was a councilor of the Mining & Metallurgical Society of America.

As an engineer and economist, Harvey Mudd was logical and exacting. He was conservative, seldom acting on impulse, but quite willing to speculate on carefully weighed hazards. He was especially considerate of those who were associated with him in enterprise and often unwilling to expose them to risks which would not have deterred him, personally.

Harvey Mudd had no political ambitions. His sense of responsibility to the public was profound, and his capacity to serve in educational, cultural, artistic, and civil endeavors was great. Well-merited recognition came to him in many ways. In 1949, Columbia University bestowed on him the high honor of the Egleston Medal for distinguished engineering achievements after awarding him the honorary degree of Doctor of Science in 1947. Honorary degrees of Doctors of Law were conferred on him by Loyola University in 1943, and by University of California, Los Angeles, in 1941. In 1935, the Los Angeles Realty Board awarded him a citation as contributor of the most valuable and unselfish service to the community.

During Harvey Mudd's lifetime his outstanding organizational and administrative ability had served many institutions. He was a trustee of the Rand Corp.; trustee of the California Institute of Technology; trustee of the American Heritage Foundation; trustee of the Southwest Museum; president of the Board of Fellows of Claremont College; and devoted in his services to all the Claremont Colleges. From 1934 to 1946, as president of the Southern California Symphony Assn., which sponsors the Los Angeles Philharmonic Orchestra, he was the tireless leader of a group who kept the orchestra alive through several difficult seasons. He was a director of the Los Angeles Welfare Federation, which sponsors the Los Angeles Community Chest. He was a member of the board of governors of the Los Angeles Museum of History, Science, and Art; member of the Advisory Board of the Henry E. Huntington Library and Art Gallery; chairman of the Board of Greater Los Angeles Plans, Inc.; a director of the Good Samaritan Hospital.

For many years the American Institute of Mining, Metallurgical, and Petroleum Engineers was dear to Harvey Mudd. He was elected a member in 1917, serving as Director 1923 to 1935, 1940 to 1944, 1946 to 1948; as Vice President from 1937 to 1940, and from 1943 to 1945, when he became President for the customary term of one year. He was a diligent worker on several important committees and a Director on the Board of the Seeley W. Mudd Memorial Fund Committee for the advancement of sciences and arts of mining and metallurgy, established by Mrs. Seeley W. Mudd and her sons, Harvey Seeley Mudd and Dr. Seeley Greenleaf Mudd. On committees as Director, and during his terms as President and Vice President, he gave unsparingly of his time and broad experience in planning programs and procedures for the improvement of the Institute.

As one of those friends and associates who have benefited most from the genuinely warm personality, friendly cooperation, and sensible counsel of Harvey Mudd, I especially appreciate the great loss and sorrow in his passing, and sympathize deeply with his family and other friends.

Daniel Worth Butner

An Appreciation by
Earl Volin

Daniel Worth Butner (Member 1917) was stricken by a heart attack at his desk at the office of the U. S. Bureau of Mines, Spokane, on the morning of Feb. 10, 1955 and died that night in a hospital. Although his health had been failing for some time, he persisted in working to the last. He is survived by his widow, Edith Elliot, sons Daniel Worth and Myles and a daughter, Joan Emily. His death is mourned by a multitude of friends who became acquainted with him in his wide travels and were attracted by his sincere manner and warm interest in others.

Dan was born in Winston-Salem, N. C., on Dec. 8, 1890 to Thaddeus M. and Emily (Worth) Butner. Seeking a mining career he enrolled at Colorado School of Mines and graduated in 1915 with the degree of Engineer of Mines. His first job was with Utah Metals Co., Bingham Canyon, Utah, but soon he went to Mexico to work for Cinco Mines Co. After a brief time there he returned to the U. S. to become foreman for Molybdenum Products Co. at Tucson, Ariz. The urge to travel then took him to Cuba where he was superintendent for Bethlehem Steel Co. in 1917 to 1918. He returned to the U. S. to enter military service; he took part in World War I with the Corps of Engineers in France and during his term of service rose from the grade of private to second lieutenant. In 1920 the beckoning of far places took him to the Belgian Congo to become assistant manager, and later manager of the Kambove Mine Co. In 1923 he returned to the U. S. to take the position of superintendent of the Holly mine in Nevada, and soon thereafter became engineer at the famous 16 to 1 mine at Alleghany, Calif. He went back to Africa in 1924 to take the position of mine superintendent for Rhodesian Copper Mines, and later he became assistant manager. The phenomenal growth of the Philippine mining industry in the early 1930's attracted him and he took the position of general superintendent of Benguet Gold Mining Co., serving in that capacity from 1932 to 1937. His return to the U. S. marked the end of his foreign work. In 1938 he started searching for extensions of the gold placer deposits under the lava flows in Calaveras County, Calif.; although he brought new methods to bear on the problems, this venture drew so heavily upon his savings that he abandoned it in 1941. The same year, he came to the Bureau of Mines as field engineer at Tucson, Ariz., to work ably and faithfully on the Strategic Minerals Exploration program during World War II and the post-war programs under Conservation & Development of Mineral Resources. Wartime expansion and post-war contraction of these programs caused him to move first to Reno, Nev., and then to San Francisco, then to Albany, Ore., and finally in 1952 to Spokane. At the time of his death, he held the position of assistant chief of the Mining Div., Spokane field office, Region I.

Besides his long membership in AIME, Dan was a registered professional engineer in California, Oregon, Washington, Idaho, and Montana. He was a member of El Paso Lodge No. 13, A. F. and A. M., Colorado Springs, Colo., and also a member of the Mount Arayat Lodge of Perfection, Manila Bodies, A. and A. S. R., Manila, P. I., having attained the 32nd degree. He was an active member of the Episcopal Church, and found time for other interests including Toastmasters International and the Philatelic Club. He was an avid reader, both of science and fiction books, and he accumulated a small but valuable library.

Dan's outstanding trait was his gentle disposition; this with his always courteous manner developed lasting friendships among his many acquaintances he made in his wide travels. Slow to speak because of careful forethought about what he had to say, he expressed himself with clarity, impressive sincerity, and frankness. His written reports and letters were concise and conclusive. A quiet sense of humor, not in contrast to his reserved manner, dis-

Necrology

Date of Election	Name	Date of Death
1912	Charles J. Adami	Mar. 28, 1955
1906	O. U. Bradley	Unknown
1904	H. McL. Cobb	Aug. 25, 1954
1937	Thomas E. Costner	Unknown
1940	Harry E. Crum	1955
1922	Gustav Egloff	Apr. 29, 1955
1941	L. H. Hinckley	Mar. 25, 1955
1953	J. W. R. Husen	Mar. 23, 1955
1954	Richard D. Mendoza	Unknown
1917	H. S. Mudd	Apr. 12, 1955
1953	Walter G. Pijawka	Mar. 5, 1954
1942	Robert D. Pike	Apr. 13, 1955
1948	Eugene G. Snedaker	Apr. 7, 1955
1939	Cleve A. Stover	Dec. 18, 1954
1949	Willis W. Wiedenman	Apr. 10, 1955
1924	O. Barlow Willmarth	Unknown

tinguished his speech and writing. This characteristic served to keep him cheerful even under the burden of ill health.

Dan was deeply devoted to his family and home. He also was devoted to his work with the Bureau of Mines and was unfailing in his sense of duty to the public. Perhaps his greatest contribution, however, was his unceasing interest in encouraging the younger engineers in their careers. The counseling readily available for the asking, the stimulation that came from discussions with him and the constructive criticisms that were helpful to reports he reviewed—these among other things will always be associated with memories of him.

To our sorrow, a man of outstanding honesty and sincerity, a friend always helpful and understanding, has departed from our midst.

G. Lister Carlisle (Member 1916) died Dec. 22, 1954 in Norwalk, Conn. He was a well-known mining engineer and conservationist. Mr. Carlisle was born in New York in 1877 and studied at Sheffield Scientific School, Yale University, graduating with the class of 1900. Although educated to be a mechanical engineer, he entered mining with the design of the breaker at the Auchincloss mine in Pennsylvania and from 1901 to 1902 was in charge of the erection of this breaker. In 1903 Mr. Carlisle went to Nicaragua where he remained for eight years, acquiring interests in various properties, including 50 pct interest in the Babilonia gold mine, La Libertad district. Later he opened offices in New York. Mr. Carlisle financed and took part in the Carlisle-Clark 1928 African expedition of the American Museum of Natural History. This expedition, which spent more than ten months in Tanganyika, acquired seven perfect lion specimens for the Akeley African Hall of the Museum. Mr. Carlisle was a trustee of Berry College, Rome, Ga., and a member of the board, American Geographical Society. He was a member of the National Audubon Soc., Yale Engineering Assn., and the Explorers Club.

Joseph F. Featherstone (Member 1951) died Jan. 16, 1955. He was president and general manager of Commonwealth Lead Mining Co., Salt Lake City. Mr. Featherstone acquired operating control of this company in 1948 and began developing ore in 1950. He was born in American Fork, Utah, in 1881 and studied at Brigham Young University. After working for several years as general manager for sugar refining companies, Mr. Featherstone joined Park Galena Mining Co. in 1924 and designed and erected a flotation mill for this company in 1926. Park Galena mine, later sold to New Park Mining Co., is now one of the largest producers in the district. As general manager for Western Alloys Co., Salt Lake City, from 1940 to 1943, Mr. Featherstone designed and erected a manganese beneficiation plant. He served as principal operating engineer for the War Relocation Authority from 1943 to 1946.

Robert F. Gillette (Member 1954) died Sept. 4, 1954. He was a student at Colorado School of Mines, Golden, Colo., and expected to graduate in 1955 as a geological engineer. During the summer of 1953 Mr. Gillette gained experience as a surveyor in Queens, N. Y. He was a member of A.T.O.

B. Britton Gottsberger (Legion of Honor Member 1901) died Feb. 28, 1955 in New Haven, Conn., at the age of 82. He was a consulting mining engineer and a director of mining companies. Mr. Gottsberger received his degree in engineering from Columbia University in 1895. He gained his early experience in Mexico and in 1900 joined Tennessee Copper Co., Copper Hill, Tenn., as a mining engineer. Among his many other positions, Mr. Gottsberger was general manager, Miami Copper Co., Miami, Ariz., professor of mining, Yale University, and consulting engineer, Centrifugal Pipe Corp., Jersey City.

David E. Green (Member 1939) died Dec. 1, 1954 of a heart attack. Mr. Green was owner and operator of Coachella Engineering Laboratory, Coachella, Calif. He was born in 1907 in West Orange, N. J., and received his A.B. in chemistry from Harvard University in 1927 and his E.M. in mining from Stanford University in 1930. Mr. Green was later a geological draftsman with Associated Oil Co., San Francisco, a flotation mill operator, McDonald Tailing Lease, Grass Valley, Calif., and a mine shift boss, Miami Copper Co., Miami, Ariz. He was also at various times a research chemist with Western Sugar Refinery, San Francisco, a chemist with Smith-Emery Co., Los Angeles, and a research chemist with Filtrol Co., Los Angeles. During World War II, Mr. Green served as a surveyor with H & S Co., 835 Engineers, Aviation Branch.

Henry Hardenbergh (Member 1945) died Feb. 9, 1955. He was chairman of the board of directors of The New Jersey Zinc Co., New York. Mr. Hardenbergh was born in New York on Dec. 28, 1882 and, after graduation from Harvard University in 1904, joined The New Jersey Zinc Co. in 1905 as a chemist. Advancing through the organization he was elected president and director in 1943 and in 1951, chairman of the board. Mr. Hardenbergh was a member of the Harvard Club, the University Club, American Mining Congress, and American Zinc Institute.

Theodore J. Hoover (Legion of Honor Member 1900) died Feb. 4, 1955 of a cerebral hemorrhage at his home, Casa del Oso, Davenport, Calif. Mr. Hoover, elder brother of former President Herbert Hoover, was dean emeritus of Stanford University School of Engineering. He was born in West Branch, Iowa, in 1871 and received his B.A. from Stanford in 1901. Mr. Hoover first worked as an assayer at the Keystone mine, Amador City, Calif. In 1903 he started work as assistant superintendent, Standard Consolidated Mining Co., Bodie, Calif., and became superintendent the following year. For the next 15 years Mr. Hoover was a manager or consulting engineer of mines in California, Mexico, Russia, Burma, Australia, and Alaska. In 1919 he became professor of mining and metallurgy at Stanford University and served as dean of engineering from 1925 to 1936. In 1940 Mr. Hoover disposed of his holdings in one of the world's largest mercury producers, the New Idria Quicksilver Mining Co., San Benito County, Calif. Widely known for his work in fish and game conservation, Mr. Hoover was also the author of *Concentrating Ores by Flotation*, *Economics of Mining*, and *The Engineering Profession*.

Elton Hoyt, II, (Member 1928) died Mar. 16, 1955. Mr. Hoyt was senior managing partner, Pickands, Mather & Co., Cleveland, and was with this firm for 44 years. He was born in Cleveland in 1888 and received his B.A. from Yale University in 1910. Last year Mr. Hoyt was awarded the Gary Medal for distinguished service to the iron and steel industry. He was the first person outside the immediate limits of that industry to receive this honor. During World War II Mr. Hoyt organized the Lake Vessel Committee, which regulated vessel traffic on the Great Lakes. He was president of Mather Iron Co. and Interlake Steamship Co. and a director of Interlake Iron Corp., Youngstown Steel Door Co., and Pittsburgh & Lake Erie RR.

William J. Kuntz (Member 1941) died Jan. 28, 1955. He was a lime plant engineer. Mr. Kuntz was president and general manager Lime & Hydrate Plants Co., York, Pa. He was born in York in 1879. Among other companies, Mr. Kuntz was employed by Ruggles-Coles Engineering Co., York, and Blaw-Knox Co., Pittsburgh. He was also at one time president, McGann Mfg. Co., York.

John Morton Lee (Member 1923) died Feb. 6, 1955. Mr. Lee was an advisory director to Dorr-Oliver Co. Ltd., London. He was managing director of this company until he retired two years ago. Mr. Lee was born in Norwood, London, in 1887 and received his early education in Paris. He first worked as an apprentice for George Wailes & Co., London, and then as a junior assistant engineer, Waterlov & Sons Ltd. In 1910 he joined the Wilfley Mining Machinery Co. in London as an engi-

neer and draftsman. Mr. Lee returned to this company after service in World War I with the 2nd London Field Co. Royal Engineers. He was responsible for many important contracts for grinding and concentrating plants, machinery, and furnace residue recovery plants in Great Britain and Africa. Mr. Lee was a co-inventor of improvements on centrifugal pumps. He was managing director of Oliver United Filters Inc. in London when Oliver United and The Dorr Co. combined in 1932.

Edgar C. Long (Member 1936) died Nov. 28, 1954 in Las Vegas, Nev. He was magnesium superintendent, production dept., Titanium Metals Corp. of America, a joint venture of National Lead Co. and Allegheny Ludlum Steel Corp. Mr. Long had been with National Lead Co. and its affiliates since 1930 when he received his B.S. degree from Missouri School of Mines. He was born in Rolla, Mo., in 1908. Mr. Long entered the Army in 1942 as a lieutenant and was discharged in 1946 as a major. He saw service in Africa and Europe.

James B. McKay

An Appreciation by

J. R. Powers

James B. McKay, research engineer for the Du Pont Co. at Starke, Fla., died Jan. 28, 1955 as a result of an automobile accident near Keystone Heights, Fla. He was 40 years old.

Jim was born on Sept. 17, 1914 in Savanna, Ill. He attended both Antioch College and Cornell College briefly before turning his interests to mining. He went to the New Mexico School of Mines and received a B.S. in general science in 1940 and a B.S. in mining engineering in 1941.

After graduation, he was employed by The Dorr Co. in Westport, Conn. He became a research engineer in this organization, working mainly in the mineral dressing field. Later, he became interested in fluidized solids, going into sales in 1947. He made many contributions to the development of the fluidized solids technique, particularly for sulphide roasting. Jim was issued several patents in this and other fields and was the author of several related papers.

In 1949, he became mill superintendent at the Balmerton, Ont., gold mill of the Campbell Red Lakes Mines Ltd. In this capacity, Jim helped to improve the performance of the plant, particularly the Fluo-Solids roaster.

He returned to The Dorr Co. as a sales engineer in 1951. In July 1952, he joined Du Pont and initiated a research study into gravity concentrators for recovering titanium minerals from Florida beach sand deposits. This work was carried out at Starke, Fla., where the Humphreys Gold Corp. operates two plants for Du Pont. Jim has made some major contributions in this field, the results of which have not been fully realized.

In addition to being a member of the AIME (1947), he was also a member of the Canadian Institute of Mining Engineers.

Jim was very creative, always reaching out for new horizons in the technical field. He was an unusually hard and enthusiastic worker. His use of the English language in conversation was almost without equal —he always had the right word and an illustrative metaphor.

Jim McKay was also very active in community affairs. He had recently been elected to the Town Council of Keystone Heights, Fla. He was a hard-working member of the Volunteer Fire Dept., the Lions Club, and P.T.A. His projects around town will preserve his memory for a long time.

He is survived by his wife, Faith McKay, and four children.

John T. Parker (Member 1942) died suddenly Jan. 12, 1955 in Cleveland of acute lukemia. He was manager of Inland Steel Co. steel properties at Wheelwright, Ky. Mr. Parker was born in Fayette City, Pa., in 1901. In 1918 he went to work in the engineering dept., Union Collieries Co., Pittsburgh, and later studied at Carnegie Institute of Technology. Mr. Parker was first employed by Inland in 1926 as a mining engineer at Indianola, Pa., but was transferred four years later to Wheelwright where he was successively mine engineer, mine superintendent, and general superintendent before becoming manager a year ago. Long prominent in coal industry organizations, Mr. Parker was a member of the mining development committee of Bituminous Coal Research, the operating committee of the Bituminous Coal Operators Assn., and the program committee for the 1955 American Mining Congress. He was a past president and director of both the Kentucky Mining Institute and the Big Sandy-Elkhorn Mining Institute, and a chairman of the Appalachian Section of the AIME.

Walter G. Parker (Member 1952) died of polio Sept. 18, 1954. He was a metallurgist with Western Knapp Engineering Co., San Francisco. Mr. Parker was born in West Haven, Conn., in 1919 and received a degree from Montana School of Mines in 1953. During World War II he served in the U. S. Air Force as an aircraft mechanic and an air-rescue technician.

John Roger (Member 1920) died Mar. 7, 1955 in New York. He and the late Thomas B. Stearns founded in 1886 the Stearns-Roger Mfg. Co. in Denver. Its plant was in Pueblo, Colo. Mr. Roger was vice president of the company from its incorporation in 1891 until his retirement in 1908. He was born in Scotland in 1858.

Paul E. Sellers (Member 1949) died Oct. 7, 1954. Mr. Sellers was a superintendent with the Bethlehem Div., Bethlehem Steel Co., Bethlehem, Pa. He was born in Steelton, Pa., in 1890. In 1905 Mr. Sellers started work as a machinist apprentice for Pennsylvania Steel Co. and from 1916 to 1926 worked as an assembly foreman in the maintenance shop of the Steelton plant. He became a master mechanic in the Bethlehem quarry, Bethlehem Steel, in 1926 and was made superintendent, stone & slag, in 1938.

Memorial Resolution

in honor of

Swain Joseph Swainson

Whereas, our very good friend and Past Chairman of Minerals Beneficiation Div. died on October 22 after a prolonged illness from cancer.

This had affected him for more than two years; he knew what was coming, but you never would have guessed it from talking with him. His courage and vitality were remarkable.

Joe Swainson was an outstanding metallurgist. He headed up the Ore Dressing Div. of American Cyanamid and had charge of that division's testing laboratories at Stamford, Conn., for many years. He was responsible for putting Aerofloat and many other of American Cyanamid's flotation reagents on the market. He was responsible for the successful exploitation of the Heavy-Media process, now so widely used for concentrating iron ore and for rejecting gangue in many concentration operations. He was intimately connected with the work in atomic energy and for several years was in charge of the Winchester Laboratory of the AEC, at the time when American Cyanamid had the contract for operating this laboratory.

Joe did yeoman service for the AIME. For several years he was active in the affairs of the Minerals Beneficiation Div., starting about the time the Division was first formed, and was one of the early stalwarts who succeeded in forging the Minerals Beneficiation Div. out of the former Milling Methods Committee. He held various offices in the Division and finally became its Chairman. It was characteristic of Joe that he tried to refuse this office, saying that he thought an operating man, rather than the representative of a company selling supplies to the industry, should guide the destinies of MBD. It was, in fact, somewhat difficult to convince him that he was just as high grade an engineer as any of the operators who were active in Division affairs. Certainly he made a very fine Chairman and the Division owes much to his leadership:

Therefore Be It Resolved, that the Minerals Beneficiation Division and the American Institute of Mining, and Metallurgical Engineers record with deep sorrow the loss of this distinguished engineer and fine friend.

By the

Minerals Beneficiation Division

MEMBERSHIP

Proposed for Membership
Mining Branch, Aime

Total AIME membership on Apr. 30, 1955 was 22,499; in addition 1687 Student Associates were enrolled.

ADMISSIONS COMMITTEE

P. D. Wilson, Chairman; F. A. Ayer, Vice-Chairman; A. C. Brinker, R. H. Dickson, T. D. Jones, F. T. Hanson, Sidney Rolle, O. B. J. Fraser, F. T. Sisco, Frank T. Weems, R. L. Ziegfield, R. B. Caples, F. W. McQuiston, Jr., A. R. Lytle, H. R. Wheeler, L. P. Warriner, J. H. Scaff.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

Alabama
Bessemer—Moore, August A. (J)
Bessemer—Sutton, Glen W. (M)
Bessemer—Wickstrom, Walter W. (M)
Birmingham—Files, Edgar J. (M)
Birmingham—Sides, Glenn H. (R. C/S—S-M)
Arizona
Morenci—Cross, Richard R. (M)
Morenci—McLean, Leslie D. (M)
Phoenix—Still, Robert C. (A)
Scottsdale—Lipphardt, Lomis E. (A)
Colorado
Grand Junction—Dulaney, Richard O. (A)
Florida
Bartow—Byrum, Alvin S. (M)
Brewster—Timberlake, Richard C. (R. A)
Lakeland—Fort, William R. (M)
Lakeland—Purcell, Edward J. (M)
Illinois
Evanston—Pettyjohn, Elmore S. (A)
Louisiana
Shreveport—Stevens, George R. (R. M)
Massachusetts
Cambridge—Charles, Richard J. (J)
Minnesota
Duluth—Chisholm, Donald M. (M)
Nevada
Henderson—Taylor, Glen C. (C/S—A-M)
New Jersey
Pompton Plains—Culbertson, Francis D. (C/S—A-M)
Ridgefield—Wilson, Thomas A. (R. C/S—S-J)
New Mexico
Carlsbad—Jackson, Albert S. (A)
Grants—Boyden, Thomas A. (A)
Grants—Pate, Jack R. (M)
New York
Tahawus—Van Meter, William S., Jr. (M)
Ohio
Cincinnati—Robertson, Alex. E. (A)
Youngstown—Walsh, Francis N. (A)
Pennsylvania
Bentleyville—Conrad, Olen E. (C/S—A-M)
Dover—Brigstocke, Horace D. (A)
Jeddo—Markle, Donald, Jr. (M)
Pittsburgh—Wellborn, William W. (M)
State College—du Breuil, Felix L. (C/S—A-M)
West Chester—Haseman, Joseph F. (C/S—A-M)
Texas
El Paso—Seyffert, Willis A. (A)
Utah
Kearns—Patterson, Lowell A. (A)
Moab—Norman, Robert R. (M)
Murray—Shaw, Harold J. (M)
Salt Lake City—Mahoney, Stanford R. (R. C/S—S-M)
Salt Lake City—Robertson, Daniel B. (M)
West Virginia
Red Jacket—Williams, Cyril H. (R. M)
Wisconsin
Milwaukee—Mueller, Albert P. (A)
Alaska
Anchorage—Schmidt, George R. (C/S—A-M)
Canada
Kirkland Lake, Ont.—Falconer, Duncan J. (M)
Chile
Chuquicamata—Kazmiersky, Harry M. M. (J)
Colombia
Otu—DuBoulay, George M. (J)
India
Anand, Bombay State—Patel, Hasmukhbhai R. (C/S—S-J)
Mexico
Chihuahua—Arroyo, Cesar S. (M)
Chihuahua—Brown, Ray (M)
N. Rosita, Coah.—Martinez, Baltazar (C/S—A-M)
Peru
Cerro de Pasco—Galvan, Carlos (J)
Lima—Lilly, Gordon F. (A)
Uganda
Entebbe—Brown, James M. (M)

Coming Events

June 14-16, Conference on Magnetism and Magnetic Materials, AIEE, AIME, American Physical Society, Carnegie Institute of Technology, William Penn Hotel, Pittsburgh.

June 17, AIME, Spokane Subsection, Desert Hotel, Spokane.

June 18, AIME, Colorado Plateau Section, spring meeting, Grand Imperial Hotel, Silverton, Colo.

June 18-July 3, Centenary Congress of the Société de l'Industrie Minérale, Paris.

June 20-24, American Society of Engineering Education, 63rd annual meeting, Pennsylvania State University, State College, Pa.

June 25, AIME, Adirondack Section, Gouverneur Country Club, Gouverneur, N. Y. Golf, plant tours, and H. DeWitt Smith tells "Tsumeb Story."

June 26-July 1, American Society for Testing Materials, annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

June 28-July 9, International Electrochemical Commission, London.

July 7, AIME, Utah Uranium Subsection, 7:30 pm, Arches Cafe, Moab.

July 30, AIME, Adirondack Section, National Lead Co., Tahawus, N. Y. Plant tour; mining symposium.

Aug. 27, AIME, Adirondack Section, Tupper Lake Country Club, Tupper Lake, N. Y. John F. Meyers, speaker. Golf tournament.

Sept. 25-28, American Institute of Chemical Engineers, Lake Placid Club, Lake Placid, N. Y.

Oct. 2-5, AIME MGGD fall meeting and Black Hills regional meeting of the Ind. Min. Div., Rapid City, S. D.

Oct. 6-8, AIME, Minerals Beneficiation Div., fall meeting, **Rocky Mountain Minerals Conference,** Salt Lake City.

Oct. 10-13, American Mining Congress, Metal Mining—Industrial Minerals Convention, Las Vegas, Nev.

Oct. 13-15, Annual Drilling Symposium, School of Mines and Metallurgy and the Center for Continuation Study, University of Minnesota, Minneapolis.

Oct. 17-19, AIME, IMD, fall meeting, Adelphia Hotel, Philadelphia.

Oct. 17-21, National Safety Congress and Exposition, Conrad Hilton, Congress, Morrison, and La Salle hotels, Chicago.

Oct. 19-20, ASME, AIME, fuels conference, Neil House, Columbus, Ohio.

Oct. 27-29, AIME, Industrial Minerals Div., fall meeting, Hotel Charlotte, Charlotte, N. C.

Nov. 4, AIME, NOHC, Pittsburgh Local Sections, off-the-record meeting, Pittsburgh.

Nov. 13-18, American Society of Mechanical Engineers, Diamond Jubilee annual meeting, Congress, Hilton, and Blackstone Hotels, Chicago.

Feb. 20-23, 1956, AIME, Annual Meeting, Statler and New Yorker hotels, New York.

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